KPK BOARD NOTES

CHEMISTRY

10TH CLASS

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Unit 9

Chemical Equilibrium

Q. 1 Define a chemical reaction.

Ans. **Chemical reaction:**

A chemical reaction is a chemical change in which one or more than one substance is converted to one or more different substances. In a chemical reaction, we have two types of substances i.e. reactants and products.

Reactants:

Those substances, which combine to form new substances in a chemical reaction, are called reactants.

Products:

Those substances, which are formed as a result of chemical reaction of reactants, are called products.

Example:

When one mole of nitrogen gas (N_2) and 3 moles of hydrogen gas (H_2) are combined in a chemical reaction, they form two moles of ammonia (NH_3).

$$N_{2(g)} + 3H_{2(g)} \longrightarrow 2NH_{3(g)}$$

In the above reaction, Nitrogen and Hydrogen are the reactants and Ammonia is the product, formed as a result of chemical reaction between Nitrogen and Hydrogen.

Q.2 Differentiate between "Irreversible Reactions" and "Reversible Reactions."

Ans. **Irreversible Reactions**

Definition:

Irreversible reactions are those reactions in which the products do not recombine to form the reactants. OR

Those reactions, which cannot get easily reversed, are called irreversible reactions.

Characteristics of Irreversible Reaction

i. Irreversible reactions stop upon completion.
ii. They can proceed to completion.
iii. These reactions start from the side of reactants only.
iv. They proceed only in one direction.
v. Equilibrium cannot be established in these reactions.
vi. They are represented by putting a single arrow ($\longrightarrow$) in between the reactants and products.

Example:

The reaction of magnesium (Mg) with excess of hydrochloric acid (HCl) is an irreversible reaction because magnesium chloride and hydrogen gas formed as a result of their (Mg+HCl) reaction, do not react to form magnesium and hydrochloric acid again.

Chemical reaction:

$$Mg_{(s)} + 2HCl_{(l)} \longrightarrow MgCl_{2(l)} + H_{2(g)}$$

Other examples of irreversible reactions are burning of natural gas in the presence of oxygen and reaction of sodium chloride (NaCl) with silver nitrate ($AgNO_3$).

$$CH_{4(g)} + O_{2(g)} \longrightarrow CO_{2(g)} + H_2O_{(g)}$$

$$NaCl_{(aq)} + AgNO_{3(aq)} \longrightarrow AgCl_{(s)} + NaNO_{3(aq)}$$

Representation:

Ir-Reversible reactions are represented by putting a single arrow ($\longrightarrow$) in between the reactants and products which means that the reactants once consumed cannot be easily reproduced i.e. the reaction only proceeds in forward direction.

Unit - 9 Chemical Equilibrium

Reversible reactions

Definition:

Those reactions in which the products can react to form the reactants again are called reversible reactions.

OR

Those reactions which can be reversed easily are called reversible reactions.

Characteristics of Reversible Reaction

i. Reversible reactions never stop.
ii. These reactions never go to completion
iii. Reversible reactions can be started from either sides.
iv. These reactions proceed in both directions.
v. Equilibrium is established in these reactions.
vi. They are represented by putting a double half headed arrow ($\rightleftharpoons$) in between the reactants and products.

Example

Mercuric oxide (HgO) when heated in a closed test tube decomposes to mercury (Hg) and oxygen (O_2), but at the same time, mercury and oxygen recombine to form HgO again. Therefore, we can say that this reaction is a reversible reaction.

$$2HgO_{(s)} \rightleftharpoons 2Hg_{(l)} + O_{2(g)}$$

Besides this, the reaction of sulphur dioxide with oxygen and hydrogen with iodine are also examples of reversible reactions.

$$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$$

$$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$$

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- گروپ میں معزز، پڑھے لکھے، سلجھے ہوئے ممبرز موجود ہیں اخلاقیات کی پابندی کریں اور گروپ رولز کو فالو کریں بصورت دیگر معزز ممبرز کی بہتری کی خاطر ریموو کر دیا جائے گا۔
- کوئی بھی ممبر کسی بھی ممبر کو انباکس میں میسج، مس کال، کال نہیں کرے گا۔ رپورٹ پر فوری ریموو کر کے کاروائی عمل میں لائے جائے گی۔
- ہمارے کسی بھی گروپ میں سیاسی و فرقہ واریت کی بحث کی قطعاً کوئی گنجائش نہیں ہے۔
- اگر کسی کو بھی گروپ کے متعلق کسی قسم کی شکایت یا تجویز کی صورت میں ایڈمن سے رابطہ کیجئے۔
- سب سے اہم بات:

گروپ میں کسی بھی قادیانی، مرزائی، احمدی، گستاخِ رسول، گستاخِ امہات المؤمنین، گستاخِ صحابہ و خلفائے راشدین حضرت ابو بکر صدیق، حضرت عمر فاروق، حضرت عثمان غنی، حضرت علی المرتضیٰ، حضرت حسنین کریمین رضوان اللہ تعالیٰ اجمعین، گستاخِ اہلبیت یا ایسے غیر مسلم جو اسلام اور پاکستان کے خلاف پراپیگنڈا میں مصروف ہیں یا ان کے روحانی و ذہنی سپورٹرز کے لئے کوئی گنجائش نہیں ہے لہذا ایسے اشخاص بالکل بھی گروپ جوائن کرنے کی زحمت نہ کریں۔ معلوم ہونے پر فوراً ریموو کر دیا جائے گا۔

- تمام کتب انٹرنیٹ سے تلاش / ڈاؤنلوڈ کر کے **فری آف کاسٹ** وٹس ایپ گروپ میں شیئر کی جاتی ہیں۔ جو کتاب نہیں ملتی اس کے لئے معذرت کر لی جاتی ہے۔ جس میں محنت بھی صَرف ہوتی ہے لیکن ہمیں آپ سے صرف دعاؤں کی درخواست ہے۔
- عمران سیریز کے شوقین کیلئے علیحدہ سے عمران سیریز گروپ موجود ہے۔
- **لیڈیز کے لئے الگ گروپ کی سہولت موجود ہے جس کے لئے ویریفکیشن ضروری ہے۔**
- اردو کتب / عمران سیریز یا سٹڈی گروپ میں ایڈ ہونے کے لئے ایڈمن سے وٹس ایپ پر بذریعہ میسج رابطہ کریں اور جواب کا انتظار فرمائیں۔ برائے مہربانی اخلاقیات کا خیال رکھتے ہوئے موبائل پر کال یا ایم ایس کرنے کی کوشش ہرگز نہ کریں۔ ورنہ گروپس سے تو ریموو کیا ہی جائے گا بلاک بھی کیا جائے گا۔

نوٹ: ہمارے کسی گروپ کی کوئی فیس نہیں ہے۔ سب فی سبیل اللہ ہے

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اللہ تبارک تعالیٰ ہم سب کا حامی وناصر ہو

Representation

In a reversible reaction the reactants and products are separated by double half-headed arrow ($\rightleftharpoons$) which shows that the reaction can proceed in both directions.

Q.3(a) What is a chemical equilibrium?

Ans. **Chemical equilibrium**

A reversible reaction is said to be in a state of chemical equilibrium if the rate of forward reaction is equal to the rate of backward reaction and the concentration of products and reactants remain constant.

Explanation:

In a reversible reaction, two types of reactions occur simultaneously i.e. forward reaction and reverse reaction. Forward reaction is the conversion of reactants into products and reverse reaction is the conversion of products back into reactants.

It can be easily understand by considering a general chemical reaction in which two reactants A and B react to form C and D.

$$A + B \rightleftharpoons C + D$$

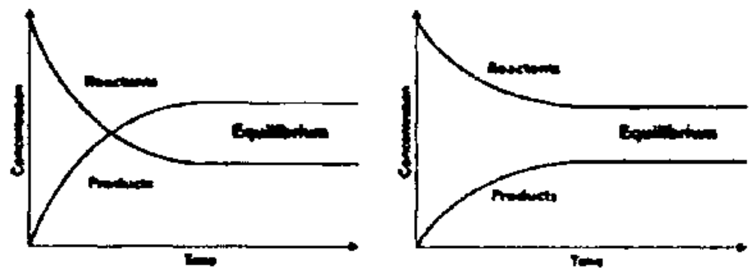
Initially, when no reaction has taken place, concentrations of A and B is maximum, and concentration of C and D is zero, but as the forward reaction proceeds the formation of C and D takes place which results in decrease of concentrations of A and B.

With the passage of time, the reaction also starts in reverse direction i.e. C and D are converted back into A and B. After some time, the rate of forward reaction becomes equal to the rate of reverse reaction. Now at this point, the concentration of both the reactants and products attain a constant value and there is no net change in the

concentration of reactants and products. The reaction seems to be stop because no more products are formed.

In fact, a reversible reaction does not stop and never goes to completion rather both the forward and reverse reactions occur simultaneously, at the same rate. Consequently, no change could be observed in the concentrations of products and reactants. Such equilibrium in a reversible reaction is called dynamic equilibrium.

Graphical representation of chemical equilibrium:



Rate of forward reaction:

Change in concentration of reactants per unit time is called rate of forward reaction.

Rate of reverse reaction:

Change in concentration of products per unit time is called rate of reverse reaction.

Mathematically,

$$\text{Rate} = \frac{\Delta(x)}{\Delta t}$$

Where $\Delta(x)$ = change in concentrati .n of product orreactant.

Examples of chemical equilibrium:

Oxidation of Sulfur dioxide to sulfur trioxide is an

example of chemical equilibrium.

$$2SO_{2\,(g)} + O_{2\,(g)} \rightleftharpoons 2SO_{3\,(g)}$$

Reaction of hydrogen and iodine to form hydrogen iodide is also an example of chemical equilibrium

$$H_{2\,(g)} + I_{2\,(g)} \rightleftharpoons 2HI_{(g)}$$

These two reactions never go to completion and in these reactions, the rate of forward reaction is equal to the rate of reverse reaction.

Point to remember:

The statement that "the rate of forward and reverse reaction will be equal" does not mean that the concentration of reactants and products at equilibrium will also be equal,

Rather for a given reaction at equilibrium, the concentrations of reactants and products may be different from one another but once equilibrium is achieved their concentrations would become constant i.e. no further change in either of the concentration would occur. They can have different values but constant values.

Q.3 (b) Write types of Chemical Equilibrium.

Ans.Types of Chemical Equilibrium

There are two types of chemical equilibrium i.e.

i. Homogeneous Equilibrium
ii. Heterogeneous equilibrium.

Homogeneous Equilibrium:

It is the type of equilibrium in which all the reactants and products are in the same phase. Phase means the physical state of reactants and products.

Example

The reaction of Nitrogen with Oxygen to form nitric

oxide is a good example of homogeneous equilibrium because in this reaction the reactants and products are in the same physical state i.e. Gaseous state.

Chemical Reaction

$$N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)}$$

Heterogeneous Equilibrium:

It is the type of equilibrium in whichthe reactants and products are in different phases. Phase means the physical state of reactants and products.

Example

The thermal decomposition of Calcium Carbonate ($CaCO_3$) to Calcium oxide (CaO) and Carbon dioxide (CO_2) is a good example of heterogeneous equilibrium because in this reaction $CaCO_3$ and CaO are in solid state and CO_2 is in gaseous state.

Chemical Reaction

$$CaCO_{3(s)} \rightleftharpoons CO_{2(g)} + CaO_{(s)}$$

Q.4 State law of mass action.

Ans. Law of mass action:

In 1864, two Norwegian chemists, Cato Maximilian Guldberg and Peter Waage presented Law of Mass action. This law shows a relationship between the concentration of reactants and products at equilibrium in a chemical reaction.



Cato Maximilian Guldberg Peter Waage

Statement:

The rate or speed of a chemical reaction is directly proportional to the product of the molar concentrations (active masses) of the reacting substances.

Active mass:

The term active mass represents the concentration of reactants and products in mol/dm^3 or we can say that it is the concentration of only those molecules which are taking part in a chemical reaction therefore the term active mass is also known as reactive mass or chemical activity. Active mass of a substance is expressed in terms of square brackets [ ].

Explanation:

Let us consider a general reaction, in which A and B react to form C and D i.e.

$$A + B \rightleftharpoons C + D$$

The active masses of A, B, C and D can be represented by [A], [B], [C] and [D] respectively.

From law of mass action, we know that the rate of reaction is directly proportional to the product of the concentrations of reactants, therefore;

Rate of forward reaction $\propto [A][B]$

$$R_f \propto [A][B]$$

$$R_f = K_f [A][B]$$

Where K_f represents the rate constant for forward reaction

Similarly,

Rate of reverse reaction $\propto [C][D]$

$$R_r \propto [C][D]$$

$$R_r = K_r [C][D]$$

Where K_r represents the rate constant for reverse reaction

We know that at equilibrium the rate of forward reaction is equal to rate of reverse reaction, so we can write it mathematically as

$$R_f = Rr$$

$$K_f[A][B] = K_r [C][D]$$

Rearranging this equation, we get

$$\frac{K_f}{K_r} = \frac{[C][D]}{[A][B]}$$

As we know that,

$$\frac{\text{Constant}}{\text{Constant}} = \text{Constant}$$

$$\text{Therefore,} \frac{K_f}{K_r} = K_c$$

Where K_c is called the equilibrium constant and its unit is different for different reactions. K_c will have no unit if the molar concentration of reactants and products are the same.

Q.5 Define equilibrium constant, Also, derive the expression for it. Discuss its units.

Ans. Definition:

Equilibrium constant is the ratio of the product of the concentration of substances formed(products) to the product of the concentration of substances consumed (reactants).

Each concentration term is raised to a power that is equal to the co-efficient of that substance in a chemical equation.

Explanation:

Let us consider a general reaction in which "a" moles of A reacts with "b" moles of B to form "c" moles of C and "d" moles of D

$$aA + bB \rightleftharpoons cC + dD$$

According to law of mass action

Rate of forward reaction $\propto [A]^a [B]^b$

$R_f = K_f [A]^a [B]^b$

Similarly,

Rate of reverse reaction $\propto [C]^c [D]^d$

$R_r = K_r [C]^c [D]^d$

At equilibrium

$R_f = R_r$

$K_f [A]^a [B]^b = K_r [C]^c [D]^d$

Rearranging this equation, we get

$$\frac{K_f}{K_r} = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

As $\frac{K_f}{K_r} = K_c$

Therefore, $K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$

Where K_c is the equilibrium constant and it gives several information about a reaction under consideration.

The equilibrium constant of a reaction is independent of pressure, concentration and catalyst and its value is constant for a particular reaction.

For example:

- Changing the concentrations of reactants or products

of a reversible reaction at equilibrium, may disturb the equilibrium for some time but the reaction will achieve its K_c value again.

- Similarly, introducing a catalyst to a reversible reaction would just speed up the reaction to reach the equilibrium sooner, but the value of K_c will not be changed, i.e. with or without the catalyst equilibrium constant value for a reversible reaction would remain unchanged.

Units of equilibrium constant:

The unit of K_c is not a fix value. It is different for different reactions. However, it is easy to find out the unit of K_c from a balanced chemical equation.

As we know that

$$K_c = \frac{\text{molar concentration of the products}}{\text{molar concentration of the reactants}}$$

Units of molar concentration =

moles per decimeter Cube (mol/dm^3)

OR moles per Liter (mol/L)

As there are different equilibrium constant expressions for different reactions, the K_c will be having more than one unit.

Consider the following three cases in which K_c has a specific unit for each case.

Case 1: If number of moles of products and reactants are equal

Consider the following example, in which the number of moles of products and reactants are equal.

$$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$$

1mol 1mol 2mol

$$K_c = \frac{[HI]^2}{[H_2][I_2]}$$

$$K_c = \frac{[mol/dm^3]^2}{[mol/dm^3][mol/dm^3]} = \frac{[mol/dm^3]^2}{[mol/dm^3]^2} = \text{No unit}$$

As both the units cancel each other,therefore K_c will have no unit in this case.

Case 2: If number of moles of products are greater than the reactants

Consider the following example in which the number of moles of product is greater than that of reactants.

$$N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)}$$

$$K_c = \frac{[NO_2]^2}{[N_2O_4]}$$

$$K_c = \frac{[mol/dm^3]^2}{[mol/dm^3]} = mol/dm^3$$

In this case, K_c is left with a unit of mol/dm^3.

Case 3: If number of moles of products are less than the reactants

It can be explained with the help of the following example.

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

$$K_c = \frac{[NH_3]^2}{[N_2]\,[H_2]^3}$$

$$K_c = \frac{[mol/dm^3]^2}{[mol/dm^3]\;[mol/dm^3]^3} = \frac{1}{[mol/dm^3]^2}$$

$$K_c = [mol/dm^3]^{-2}$$

The above three cases showed that K_c hasdifferent units for different reactions.

Q.6 Write down the conditions necessary for equilibrium.

Ans. When a dynamic equilibrium is attained by a chemical reaction then the reaction will be in a state of dynamic equilibrium forever until and unless certain conditions disturb the equilibrium.

Following are the conditions that are necessary to sustain equilibrium.

i. Concentration of the reactants and products

ii. Temperature of the system

iii. Pressure of the system

iv. Volume of the system

v. Catalyst must be the same during the reaction

If we keep constant all the above-mentioned conditions, then the reaction will be at equilibrium forever.

Points to remember:

- Equilibrium cannot be established in an open container because in an open container, the gaseous reactants and products may escape to the atmosphere and as a result, the equilibrium will not be attained by the system.
- A catalyst only changes the rate of a chemical reaction and it does not change the value of the equilibrium constant. It helps in attaining the equilibrium in a short time.

Q.7 How can one recognize that a system is at equilibrium?

Ans. Two methods are commonly used for recognizing the

status of a reaction i.e.

- Physical methods
- Chemical Methods

Physical methods:

Physical methods include refractometery, polarimetery, spectrophotometery etc. In physical methods, different properties of light are used for measuring the concentration of both the products and reactants in a given solution.

Chemical Methods:

Chemical methods may be titration, calorimetery etc. In chemical methods, various formulas (equations) are used for determining the unknown concentration of a substance from the known concentration of another substance.

However, in both type of methods, the concentration of the products and reactants are checked after regularintervals of time and when the concentration of reactants and products attain a constant value, reaction is said to be in equilibrium.

Q.8 Write down the importance of equilibrium constant.
(OR)
What are the important applications of equilibrium constant? (OR)
How will you predict the Direction and extent of a chemical reaction?

Ans. The value of equilibrium constant helps in determining the following information regarding a chemical reaction.

1. Direction of reaction
2. Extent of a chemical reaction
3. Effect of the external conditions on the position of

equilibrium

1. **Direction of reaction:**

Every reaction has a specific K_c value which helps in determining the direction of reaction. If we know the value of K_c for a reaction, then the direction of reaction can be determined from equilibrium constant expression, i.e.

$$K_c = \frac{\text{molar concentration of the products}}{\text{molar concentration of the reactants}}$$

The equilibrium constant expression shows that K_c is directly proportional to the concentration of the products therefore

- If the ratio of the molar concentration of the products to the reactants $\frac{[\text{products}]}{[\text{reactants}]}$ is less than the given value of K_c then the system is not at equilibrium and more products will be formed in order to attain the equilibrium so we can say that the reaction will move in forward direction for attaining equilibrium.

It is also clear from the equilibrium expression that K_c varies inversely to the concentration of the reactants so,

- If the ratio of the molar concentration of the products to the reactants $\frac{[\text{products}]}{[\text{reactants}]}$ is greater than the given value of K_c then the system is not at equilibrium and more reactants will be formed in order to attain the equilibrium so we can say that the reaction will move in reverse direction for attaining equilibrium.
- If the ratio of the molar concentration of the products to the reactants $\frac{[\text{products}]}{[\text{reactants}]}$ is equal to K_c, then the

reaction is at equilibrium.

2. **Extent of a chemical reaction:**

Extent of a chemical reaction is determined from the K_c expression. Consider a general reaction.

$$aA + bB \rightleftharpoons cC + dD$$

The K_c expression for this reaction can be written as

$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b} = \frac{[products]}{[reactants]}$$

It is obvious from K_c expression that if,

- **K_c is very small:** then it shows that the reaction has not proceeded in forward direction considerably/significantly, i.e. very less of the products are formed (such reactions are not considered favorable).
- **K_c is very large:** a large value of K_c shows that the reaction hasproceeded in forward direction to a greater extent,i.e. almost all of the reactants get converted into products (such reactions are considered favorable)
- **K_c is neither very large nor very small:** It reflects that both the products and the reactants are present to an appreciable extent in the equilibrium mixture, i.e. let's say when around 30 to 40 percent (may be 25, 35, 45 percent etc.) of the reactants get converted into products (such reactions are considered moderate).

3. **Effect of external conditions on Position of equilibrium:**

Equilibrium constant helps in determining the effect of external condition on the position of equilibrium. If external conditions as if pressure, temperature and concentration are not kept constant then the position of equilibrium will be

altered, i.e. equilibrium will be re-established at another position.

EXAMPLES

Example 9.1

Write the forward and reverse reaction for the following reversible reaction.

$$2NO_{(g)} + O_{2(g)} \rightleftharpoons 2NO_{2\,(g)}$$

Solution:

Forward reaction

$$2NO_{(g)} + O_{2(g)} \longrightarrow 2NO_{2\,(g)}$$

Reverse reaction

$$2NO_{2\,(g)} \longrightarrow 2NO_{(g)} + O_{2(g)}$$

Example 9.2

Write an equilibrium constant expression for the reaction of nitrogen and hydrogen to form ammonia at 150 to 200 atmospheric pressure and 450°C to 500°C and Iron as catalyst.

Solution:

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

$$K_c = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

Example 9.3

In equilibrium mixture, the concentration of hydrogen and iodine is 0.04 moles/dm^3 each, while that of hydrogen Iodide is 0.08 moles/dm^3. Find K_c for the following reaction.

Chemical Reaction

$$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$$

Given

$[H_2]=0.04$ mol/dm^3

$[I_2]=0.04$ mol/dm$_3$

$[HI]=0.08$ mol/dm^3

Required

$K_c=?$

Solution:

As the reaction given in the question is already balance so no need to balance the chemical equation.

We know that

$$K_c = \frac{[\text{products}]}{[\text{reactants}]}$$

$$K_c=\frac{[HI]^2}{[H_2][I_2]}$$

Putting values

$$K_c=\frac{[0.08]^2}{[0.04][0.04]}=\frac{0.08\times0.08}{0.04\times0.04}=\frac{2\times2}{1\times1}$$

$K_c=$ 4

(As number of moles of products and reactants are equal, therefore K_c will be left with no unit)

Example 9.4

For the given reaction at certain high temperature, the concentrations in a particularequilibrium mixture are $CO_{(g)}$ is 0.0600 mol/dm^3, $H_2O_{(g)}$ is 0.120 mol/dm^3, $CO_{2(g)}$ is 0.150 mol/dm^3 and $H_{2(g)}$is 0.300 mol/dm^3.

Calculate the value of equilibrium constant at this temperature.

$$CO_{(g)}+H_2O_{(g)} \rightleftharpoons CO_{2(g)}+H_{2(g)}$$

Given

$[CO] = 0.0600\ mol/dm^3$

$[H_2O] = 0.120\ mol/dm^3$

$[CO_2] = 0.150\ mol/dm^3$

$[H_2] = 0.300\ mol/dm^3$

Required:

$K_c = ?$

Solution:

The K_c can be calculated from the equilibrium constant expression i.e.

$$K_c = \frac{[products]}{[reactants]}$$

The K_c expression for this reaction can be written as

$$K_c = \frac{[CO_2][H_2]}{[CO][H_2O]}$$

Putting values

$$K_c = \frac{(0.150 mol/dm^3)(0.300 mol/dm^3)}{(0.0600 mol/dm^3)(0.120 mol/dm^3)} = 6.25$$

$K_c = 6.25$

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PROBLEMS

Practice Problem 9.1

Write the forward and reverse reaction for the following reversible reaction.

i. $C + H_2O_{(g)} \rightleftharpoons CO_{(g)} + H_{2(g)}$

ii. $4HCl_{(g)} + O_{2(g)} \rightleftharpoons 2H_2O_{(g)} + 2Cl_{2(g)}$

Solution:

i. Forward reaction

$$C + H_2O_{(g)} \longrightarrow CO_{(g)} + H_{2(g)}$$

Reverse reaction

$$CO_{(g)} + H_{2(g)} \longrightarrow C + H_2O_{(g)}$$

ii. Forward reaction

$$4HCl_{(g)} + O_{2(g)} \longrightarrow 2H_2O_{(g)} + 2Cl_{2(g)}$$

Reverse reaction

$$2H_2O_{(g)} + 2Cl_{2(g)} \longrightarrow 4HCl_{(g)} + O_{2(g)}$$

Practice Problem 9.3

Write an equilibrium constant expression for the following reversible reactions.

a. $N_{2(g)} + 2O_{2(g)} \rightleftharpoons 2NO_{2(g)}$

b. $2N_{2(g)} + O_{2(g)} \rightleftharpoons 2N_2O_{(g)}$

c. $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$

d. $PCl_{3(g)} + Cl_{2(g)} \rightleftharpoons PCl_{5(g)}$

Ans.

a. $$K_c = \frac{[NO_2]^2}{[N_2][O_2]^2}$$

b. $$K_c = \frac{[N_2O]^2}{[N_2]^2[O_2]}$$

c. $$K_c = \frac{[SO_3]^2}{[SO_2]^2[O_2]}$$

d. $K_c = \frac{[PCl_5]}{[PCl_3][Cl_2]}$

Practice problem 9.4

An equilibrium mixtures of N_2, O_2 and NO gases at 1500K is determined to consist of 6.4×10^{-3}mol/dm^3 of N_2, 1.7×10^{-3}mol/dm^{3}and 1.1×10^{-5}mol/dm^{3}of NO. What is the equilibrium constant for the system at this temperature?

Given

$[N_2] = 6.4 \times 10^{-3}$mol/dm^3

$[O_2] = 1.7\times 10^{-3}$mol/dm^3

$[NO] = 1.1 \times 10^{-5}$mol/dm^3

Required

$K_c = ?$

Chemical reaction

$N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)}$

Solution:

The equilibrium constant expression for this reaction can be written as:

$$K_c = \frac{[NO]^2}{[N_2][O_2]}$$

Putting values

$$K_c = \frac{\left[1.1\times10^{-5}\right]^2}{\left[6.4\times10^{-3}\right]\left[1.7\times10^{-3}\right]} = \frac{1.21\times10^{-10}}{10.88\times10^{-6}}$$

$K_c = 0.111 \times 10^{-10} \times 10^6$

$K_c = 0.111 \times 10^{-4}$

$K_c = 1.11 \times 10^{-5}$ mole/dm^3

EXERCISE

A. Choose the correct option.

1. At dynamic equilibrium

   a. the reverse reaction stops

   b.the forward reaction stops

   c.both forward and reverse reaction stops

   d. both forward and reverse reaction continue at the same rate

2. A reversible reaction has the following characteristics except

   a. They proceed in both direction

   b. They never complete

   c. Products do not form reactants again

   d. They are represented by $\rightleftharpoons$

3. The equilibrium constant expression for the reaction is

   $N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)}$

   a. $\frac{[2N][2O]}{[2NO]}$

   b. $\frac{[N]^2[O]^2}{[2NO]}$

   c. $\frac{[N_2][O_2]}{[NO]^2}$

   d. $\frac{[NO]^2}{[N_2][O_2]}$

4. The equilibrium constant (K_c) is:
   a. The sum of the two reactants
   b. The difference of two rate constants
   c. The ratio of the two rate constants
   d. The product of the two rate constants
5. When value of K_c is very small it shows that:
   a. Reaction will go in the forward direction
   b. Reaction will go in the reverse direction
   c. Reaction is at equilibrium
   d. Equilibrium will never establish
6. For which reaction the K_c will have no units.
   a. $4NH_{3(g)} + 5O_{2(g)} \rightleftharpoons 4NO_{(g)} + 6H_2O$
   b. $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$
   c. $N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)}$
   d. $CO_{(g)} + 3H_{2(g)} \rightleftharpoons CH_{4(g)} + H_2O_{(g)}$
7. When the value of K_c is very large it shows that
   a. Reaction is at equilibrium
   b. Equilibrium will never be achieved
   c. Reaction will move in forward direction
   d. Reaction will move in the reverse direction
8. Active mass means
   a. The total mass of reactants
   b. The total mass of products
   c. The total mass of products and reactants
   d. Concentration of reactants and products in moles per dm^3 in a dilute solution

9. For a reversible reaction $K_c = \frac{[C]^4}{[A]^3[B]^2}$ the equation will be:

a. $4C_{(g)} \rightleftharpoons 3A_{(g)} + 2B_{(g)}$

b. $4C_{(g)} \rightleftharpoons A_{3(g)} + B_{2(g)}$

c. $A_{3(g)} + B_{2(g)} \rightleftharpoons C_{4(g)}$

d. $3A_{(g)} + 2B_{(g)} \rightleftharpoons 4C_{(g)}$

10. The reaction between PCl_3 and Cl_2 will produce $PCl_{5(g)}$.

$PCl_{3(g)} + Cl_{2(g)} \rightleftharpoons PCl_{5(g)}$

The units of K_c for this reaction are:

a. Mol/dm^3

b. 1/mol.dm^3

c. dm^3/mol (Note: Answer given in book is wrong)

d. mol.dm^3

ANSWERS:

1	d	2	c	3	d	4	c	5	a
6	c	7	d	8	d	9	d	10	c

B. Write short answers to the following questions.

1. Define chemical equilibrium state with two examples.

Ans. A reversible reaction is said to be in equilibrium state when the rate of forward reaction equals the rate of reverse reaction

Examples:

Oxidation of sulfur dioxide to sulfur trioxide is an example of chemical equilibrium.

$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$

Reaction of hydrogen and iodine to form hydrogen iodide is also an example of chemical equilibrium

$$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$$

These two reactions never go to completion and in these reactions, the rate of forward reaction is equal to the rate of reverse reaction.

2. How would you identify that dynamic equilibrium is established?

Ans. Two methods i.e. physical and chemical methods are used for identifying that either dynamic equilibrium is established or not. In both methods, the concentration of the products and reactants are checked after regular interval of time and when the concentration of reactants and products attain a constant value after several readings then the reaction is said to be in equilibrium.

3. Compare the different macroscopic characteristics of forward and reverse reaction?

Ans. <u>Difference between forward and reverse reaction</u>

Forward reaction	Reverse reaction
Inforward reactions reactants react to form products	Inreverse reaction products react to form reactants
The direction of forward reaction is from left to right	The direction of reverse reaction is from right to left
The rate of forward reaction is fast in the	The rate of reverse reaction is negligible in the

beginning of the reaction	beginning of the reaction
Forward reaction slows down gradually with the passage of time.	Reverse reaction speeds up gradually

4. What information is required to predict the direction of chemical reaction?

Ans. For predicting the direction of a chemical reaction we must know

- the K_c value of a reaction
- the molar concentration ratio of the products to reactants

If both the values are known the direction can be predicted as given:

- If the ratio of the molar concentration of the products to the reactants $\frac{[\text{products}]}{[\text{reactants}]}$ is less than K_c then the reaction will move in forward direction for attaining equilibrium.
- If the ratio of the molar concentration of the products to the reactants $\frac{[\text{products}]}{[\text{reactants}]}$ is greater than K_c then the reaction will move in reverse direction for attaining equilibrium.
- If the ratio of the molar concentration of the products to the reactants $\frac{[\text{products}]}{[\text{reactants}]}$ is equal to K_c then the reaction is at equilibrium.

5. Relate the active mass with rate of a chemical reaction.

Ans. For the representation of a relation between the rate of a chemical reaction and active masses consider the following general reaction in which "a" moles of A reacts with "b" moles of B to form "c" moles of C and "d" moles of D

$$aA + bB \rightleftharpoons cC + dD$$

According to law of mass action

Rate of forward reaction $\propto [A]^a[B]^b$

$R_f = K_f\ [A]^a[B]^b$ ---------------- i

Similarly,

Rate of reverse reaction $\propto [C]^c[D]^d$

$R_r = K_r\ [C]^c[D]^d$ ---------------- ii

Equation i and ii relates the rate of a chemical reaction to the active masses presents in a chemical reaction.

6. At equilibrium a mixture of N_2, H_2 and NH_3 gas at 500°c is determined to consist of 0.602 mol/dm^3 of N_2, 0.420 mol/dm^3 of H_2 and 0.113 mol/dm^3 of NH_3. What is the equilibrium constant for the reaction at this temperature?

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

Given:

$[N_2] = 0.602$ mol/dm^3

$[H_2] = 0.420$ mol/dm^3

$[NH_3] = 0.113$ mol/dm^3

Chemical Reaction:

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

Required:

Equilibrium constant i.e. $K_c = ?$

Solution:

The K_c can be calculated from the equilibrium constant expression i.e.

$$K_c = \frac{[\text{products}]}{[\text{reactants}]}$$

The K_c expression for this reaction can be written as

$$K_c = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

Putting values

$$K_c = \frac{[0.113\ \text{mol/dm}^3]^2}{[0.602\ \text{mol/dm}^3][0.420\ \text{mol/dm}^3]^3}$$

Splitting the equation into units and values

$$K_c = \frac{[0.113]^2}{[0.602][0.420]^3}\ \frac{[\text{mol/dm}^3]^2}{[\text{mol/dm}^3][\text{mol/dm}^3]^3}$$

$$K_c = \frac{0.113}{0.602 \times 0.074}\ \frac{[\text{mol/dm}^3]^2}{[\text{mol/dm}^3]^4}$$

$$K_c = \frac{0.113}{0.045} \times \frac{1}{[\text{mol/dm}^3]^2}$$

$K_c = 0.28\ (\text{dm}^3)^2/\text{mol}^2 \text{ or } L^2/\text{mol}^2$ Ans

7. State conditions necessary for equilibrium

Ans. See Question No. 6

8. Write equilibrium constant expression for the following reactions.

a. $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

b. $2H_{2(g)} + O_{2(g)} \rightleftharpoons 2H_2O_{(g)}$

c. $4NH_{3(g)} + 5O_{2(g)} \rightleftharpoons 4NO_{(g)} + 6H_2O_{(g)}$

Ans. The equilibrium constant expressions are given below.

$$K_c = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

$$K_c = \frac{[H_2O]^2}{[H_2]^2[O_2]}$$

$$K_c = \frac{[NO]^4[H_2O]^6}{[NH_3]^4[O_2]^5}$$

9. A reaction between gaseous sulfur dioxide and oxygen gas to produce gaseous sulfur trioxide takes place at 600°C. At that temperature, the concentration of SO_2 is found to be 1.50 mol/dm³, the concentration of O_2 is 1.25 mol/dm³ and the concentration of SO_3 is 3.50 mol/dm³. Using the balanced chemical equation calculate the equilibrium constant for this system.

Given

$[SO_2] = 1.50$ mol/dm³

$[O_2] = 1.25$ mol/dm³

$[SO_3] = 3.50$ mol/dm³

Required: Equilibrium constant i.e. $K_c = ?$

Solution:

Chemical Reaction:

$$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$$

The K_c can be calculated from the equilibrium constant expression i.e.

$$K_c = \frac{[products]}{[reactants]}$$

The K_c expression for this reaction can be written as

$$K_c = \frac{[SO_3]^2}{[SO_2][O_2]^2}$$

Putting values

$$K_c = \frac{[3.50\ mol/dm^3]^2}{[1.50\ mol/dm^3]^2[1.25\ mol/dm^3]}$$

Splitting the equation into units and values

$$K_c = \frac{[3.50]^2}{[1.50]^2[1.25]} \times \frac{[mol/dm^3]^2}{[mol/dm^3]^2[mol/dm^3]}$$

$$K_c = \frac{12.25}{2.25 \times 1.25} \times \frac{[mol/dm^3]^2}{[mol/dm^3]^3}$$

$$K_c = \frac{12.25}{2.81} \times \frac{1}{[mol/dm^3]}$$

K_c=4.36dm^3/molorL/molAns.

10. Describe the effect of temperature on equilibrium constant.

Ans. The K_c value for a particular reaction is constant at constant temperature.A change in temperature will definitely results into the increase or decrease in the value of K_c depending upon the nature of reaction.

Generally, for an endothermic reaction an increase in temperature increases the value of K_c and vice versa.

For an exothermic reaction an increase in temperature decreases the value of K_c and viceversa.

C. Write detailed answers to the following questions.

1. $SO_{3(g)}$ decomposes to form $SO_{2(g)}$ and $O_{2(g)}$ for this reaction write

i. Chemical equation

ii. K_c expression

iii. Derive the unit of K_c for this reaction

Ans. i. Chemical Equation

$$2SO_{3(g)} \rightleftharpoons 2SO_{2(g)} + O_{2(g)}$$

ii. K_c expression

$$K_c = \frac{[SO_2]^2[O_2]}{[SO_3]^2}$$

iii. Unit of K_c:

$$K_c = \frac{[mol/dm^3]^2[mol/dm^3]}{[mol/dm^3]^2}$$

$$K_c = \frac{[mol/dm^3]^3}{[mol/dm^3]^2} = mol/dm^3$$

2.a) Describe the equilibrium state with the help of a graph and an example.

Ans. See Question 3

b) Define Law of mass action.

Ans. See Question 4

3. Derive an expression for equilibrium constant and explain its units.

Ans. See Question 5

4.a) K_c has different units in different reactions. Prove it with suitable examples.

Ans. See Question 5 Topic: Units of equilibrium constant.

b) How can you predict the extent of reaction from K_c value.

Ans. See Question 8 Topic: Extent of a chemical reaction.

5.a) K_c expression for a reaction is given below

$$K_c = \frac{[Cl_2]^2[H_2O]^2}{[HCl]^4[O_2]}$$

For this reaction write

i. Reactants and products

ii. Derive the units of K_c

Ans. The chemical reaction for the given K_c expression will be

$$4HCl_{(g)} + O_{2(g)} \rightleftharpoons 2H_2O_{(g)} + Cl_{2(g)}$$

i. **Reactants:** HCl and O_2.

Products: H_2O and Cl_2

ii. **Unit of K_c:**

$$\text{Unit of } K_c = \frac{[mol/dm^3]^2[mol/dm^3]}{[mol/dm^3]^4[mol/dm^3]}$$

$$= \frac{[mol/dm^3]^3}{[mol/dm^3]^5}$$

$$\text{Unit of } K_c = \frac{1}{[mol/dm^3]^2} = \left[\frac{dm^3}{mol}\right]^2$$

OR $K_c = (L/mol)^2 L^2/mol^2$ As $1dm^3 = 1$ liter

b) Explain the importance of equilibrium constant support your answer with examples.

Ans. See Question 8

Unit 10

Acids, Bases and Salts

Q.1 Write down the names of some common acids and bases. Where they are present in excess.

Ans. The names of some common acids and their sources are given below.

Types of Acids	Sources
Citric acid	Lemons
Lactic acid	Sour milk/curd
Malic acid	Apples/pears
Formic acids	Insects like ants
Oxalic acid	Spinach
Tartaric acid	Grape Juices

Names of bases and their sources/Uses:

Types of Bases	Sources/Uses
Magnesium hydroxide	Ant-acids
Sodium hydroxide	Drain cleaners
Calcium hydroxide	Slaked lime
Sodium Bicarbonate	BakingSoda/Tooth paste

Q.2 Compare the physical properties of acids and bases.

Acids	Bases
i. Acids are sour in taste.	i. Bases are bitter in taste.
ii. They turn blue litmus paper red.	ii. They turn red litmus paper to blue.
iii. They give positive hydrogen ion (H^+) when mixed with water.	iii. They give negative hydroxyl ion (OH^-) when mixed with water.

iv. Acid-base indicator like phenolphthalein is colorless in acidic medium.	iv. Acid base indicator like phenolphthalein gives pink color in basic medium.
v. Acids are not soapy to touch.	v. Bases are slippery in nature and soapy to touch
Examples: HCl, H_2SO_4 etc.	**Examples:** NaOH, KOH etc.

Q.3 State the concept of Arrhenius regarding Acids and Bases.

Ans. **Arrhenius Concept**

In 1884, a Swedish chemist Svante Arrhenius presented his concept of acids and bases.

Acids:

According to this concept,

An acid is a chemical substance that dissociates in aqueous solution to give hydrogen ions (H^+).

General Chemical Equation

The dissociation of an acid to H^+ in aqueous medium can be represented with the following general chemical equation

$$HA_{(aq)} \xrightarrow{water} H^+_{(aq)} + A^-_{(aq)}$$

Examples

Acids like Hydrochloric acid, Nitric acid and Sulfuric acid give hydrogen ion (H^+) when added to water.

$$HCl_{(l)} \xrightarrow{water} H^+_{(aq)} + Cl^-_{(aq)}$$

$$HNO_{3(l)} \xrightarrow{water} H^+_{(aq)} + NO_3^-{}_{(aq)}$$

$$H_2SO_{4(l)} \xrightarrow{water} 2H^+_{(aq)} + SO_4^{-2}{}_{(aq)}$$

As hydrogen ion(H^+) is unstable so it is present in the form of hydronium ion (H_3O^+) in aqueous solutions. $H_2O: \longrightarrow H^+$

Bases

According to this concept,

A base is a chemical substance that dissociates in aqueous solution to give hydroxide ion (OH^-)

General Chemical Equation

The dissociation of a base to OH^- in aqueous medium can be represented with the following general chemical equation

$$BOH_{(aq)} \xrightarrow{water} B^+_{(aq)} + OH^-_{(aq)}$$

Examples

Bases like NaOH, KOH, NH_4OH give hydroxyl ions (OH^-) in aqueous solutions.

$$NaOH_{(aq)} \xrightarrow{water} Na^+_{(aq)} + OH^-_{(aq)}$$

$$KOH_{(aq)} \xrightarrow{water} K^+ + OH^-_{(aq)}$$

$$NH_4OH_{(aq)} \xrightarrow{water} NH_4^+ + OH^-_{(aq)}$$

Q.4 a) Write the limitations of Arrhenius Concept.

Ans. Limitations of ArrheniusConcept

The limitations of Arrhenius conceptare given below:

i. **Limited to Hydrogen (H^+) Ion**

According to this concept only those species are acids which give hydrogen ions (H^+) in aqueous medium but there are certain species which do not contain H^+ ions but are acidic in nature. For example, $AlCl_3$, BF_3 etc.

ii. **Limited to Hydroxyl (OH^-) Ion**

According to this concept only those species are bases

which give hydroxyl ions (OH^-) in aqueous medium but there are certain species which do not containOH^- ions but are basic in nature. For example, NH_3,CaO, MgO etc.

iii. Limited to Aqueous Medium

This concept is limited to aqueous medium only for example, HCl is a strong acid, but it does not dissociate into H^+ and Cl^-ions in an organic medium like benzene (C_6H_6) (i.e. It does not explain the acidic nature of some acids in non-aqueous medium).

Q.5 Write down the Bronsted and Lowry concept of Acids and Bases.

Ans. Bronsted-Lowry Concept/ Protonic Concept

Danish chemist J.N Bronsted and English chemist T.M Lowry presented this concept in 1923. This concept is also known as Protonic concept because it is based on the transfer of proton in an acid base reaction.

Acid

According to this concept;

An acid is a substance (molecule or ion) that is a proton (H^+) donor

Base

A base is a substance (molecule or ion) that is a proton (H^+) acceptor

Examples

According to Bronsted-Lowry concept HCl, HNO_3 and H_2SO_4 are acids because they have the ability to donate proton.

Chemical Reaction

$$HCl_{(aq)} + NH_{3(aq)} \xrightarrow{water} NH_4{}^+{}_{(aq)} + Cl^-{}_{(aq)}$$

Acid (Proton donor) Base (Proton Accepter)

In the given chemical reaction HCl is an acid because it donates a proton and NH_3 is a base because it accepts a proton.

Explanation

According to this concept only those species are acids which can donate a proton and only those species are bases, which can accept a proton. It is worth mentioning that strong Arrhenius base like Sodium Hydroxide (NaOH) is not a base according to Bronsted-Lowry concept because NaOH cannot accept a proton.

No specie can be declared as a permanent acid or a permanent base according to this concept because there are certain species, which can sometime donate a proton and sometime accept a proton depending upon the type of species with which it is reacted.

Q.4 b) What are Amphoteric Substances?

Ans. Amphoteric Substances

"Those substances which can act both as an acidand a base, are known as Amphoteric substances".

Example

Water(H_2O) is an amphoteric substance, because it can donate a proton when it is treated with Ammonia (NH_3), but it acts as a base when it is treated with a strong acid like hydrochloric acid(HCl).

Reaction as an acid

The reaction is given as under

$$H_2O_{(aq)} + NH_{3(aq)} \xrightarrow{\text{water}} NH_4^+{}_{(aq)} + OH^-{}_{(aq)}$$

Acid (Proton donor)Base (Proton Accepter)

In this reaction water (H_2O) acts as an acid because it

donates a proton (H^+) and Ammonia(NH_3^+) acts as a base because it accepts a proton(H^+).

Reaction as a base

The reaction is given as under

$$\underset{\text{Acid (Proton donor)}}{HCl_{(aq)}} + \underset{\text{Base (Proton Accepter)}}{H_2O_{(aq)}} \xrightarrow{\text{water}} H_3O^+{}_{(aq)} + Cl^-{}_{(aq)}$$

In this reaction water (H_2O) acts as a base because it accepts a proton from hydrochloric acid (HCl).

Note: The amphoteric nature of water can be explained with the help of Bronsted-Lowry acid-base concept only)

Q.6 Describe the concept of conjugate Acids and Bases.

Ans. **Conjugate Acid**

"When a base accepts a proton, it becomes positively charged specie such positively charged specie can now donate a proton and is called conjugate acid".

Conjugate Base

"When an acid donates a proton, it becomes a negatively charged specie, such a negatively charged specie can now accept a proton and is called conjugate base".

Examples

$$\underset{\text{Acid}}{H_2O_{(aq)}} + \underset{\text{Base}}{NH_{3(aq)}} \xrightarrow{\text{water}} \underset{\text{Conjugate acid}}{NH_4^+{}_{(aq)}} + \underset{\text{Conjugate base}}{OH^-{}_{(aq)}}$$

$$\underset{\text{Acid}}{CH_3COOH_{(aq)}} + \underset{\text{Base}}{H_2O_{(aq)}} \xrightarrow{\text{water}} \underset{\text{Conjugate base}}{CH_3COO^-{}_{(aq)}} + \underset{\text{Conjugate acid}}{H_3O^+{}_{(aq)}}$$

Explanation

According to Bronsted-Lowry concept, in an acid-base reaction, one specie donates a proton, the other specie accepts a proton, and as a result, cation and anion are

produced. The cation (positively charged specie) produced, can now act as an acid because it can donate a proton while the anion (negatively charged specie) produced can act as a base because it can accept a proton. The cation produced by a base is called conjugate acid and the anion produced by an acid is called conjugate base.

Points to remember

- Conjugate acid of strong base is weak and conjugate acid of weak base is strong
- Conjugate base of strong acid is weak and conjugate base of weak acid is strong

Q.7 Explain the Lewis concept of acids and Bases.

Ans. **Lewis Concept/ Electronic Concept**

In 1923, G.N Lewis presented his concept of acid and base, which is based on thetransfer of electron pairs in an acid base reaction.Therefore, this concept is also known as electronic concept.

Acid

"An acid is specie (ion or molecule) that accepts or tends to accept a pair of electron"

In short, an acid will be electrophile (electron loving) in nature(i.e. it would get attracted towards electrons). An electron deficient specie whether it is neutral or positively charged is called electrophile.

Base

"A base is specie (ion or molecule) that donates or tends to donate a pair of electron"

In short, a base will be a nucleophile in nature (i.e. it would get attracted towards positive charge). Any specie whether it is neutral or negatively charged but which can

donate a pair of electrons is called nucleophile.

Examples

1. $BF_3 + :NH_3 \xrightarrow{water} [BF_3 \leftarrow :NH_3]$
   Acid, Base, Complex

2. $H^+ + :NH_3 \xrightarrow{water} [H \leftarrow :NH_3]^+$
   Acid, Base, Ammonium Ion

3. $H^+ + H_2O: \xrightarrow{water} [H_2O: \rightarrow H]^+$
   Acid, Base, Hydronium Ion

Q.8 Describe the differences between alkalis and bases.

Ans. Differences between alkalis and bases

Alkali	Base
A base that gives OH^- when dissolves in water is called Alkali.	A base is any metal oxide or hydroxide that reacts with acid to produce salt and water.
All alkalis are bases.	All bases are not alkalis.
Examples: NaOH, KOH etc.	**Examples:** Na_2O, CaO etc.

Q.9 Describe the types of acids and Bases.

Ans. Types of Acids

There are two types of acids on the bases of the number of protons (H^+) that they give in an acid base reaction.

i. Mono-Protic Acids

Those acids, which produce one proton per molecule, are called mono-protic acids.

Examples

HCl, HNO_3, HCN, CH_3COOH are mono-protic acids because these acids give only one proton when dissociated in an aqueous medium.

Chemical Equations

$$HCl_{(l)} \xrightarrow{water} H^+_{(aq)} + Cl^-_{(aq)}$$

$$HNO_{3(l)} \xrightarrow{water} H^+_{(aq)} + NO_3^-{}_{(aq)}$$

As these acids give only one proton H^+ in aqueous medium, therefore these acids are known as mono-protic acids.

ii. **Poly-Protic Acids**

Those ac ds, which produce more than one proton per molecule, are called poly-protic acids.

It is further divide into two types i.e.

a. **Di-Protic Acids**

Those acids, which produce two protons per molecule, are called di-protic acids.

Example: H_2SO_4, H_2CO_3

Chemical Equation

$$H_2SO_{4(l)} \xrightarrow{water} 2H^+_{(aq)} + SO_4^{2-}{}_{(aq)}$$

b. **Tri-protic Acids**

Those acids, which produce three protons per molecule, are called tri-protic acids.

Example: H_3PO_4

Chemical Equation

$$H_3PO_4 \xrightarrow{water} 3H^+_{(aq)} + PO_4^{3-}{}_{(aq)}$$

As these acids give more than one proton (H^+)in aqueous medium therefore these acids arecollectively known

as poly-protic acids.

Types of Bases

There are two types of bases, depending upon the number of Hydroxyl ion OH^- that they give in an acid base reaction.

i. Monoacid bases

Those bases, which produce only one hydroxyl ion (OH^-) per molecule in aqueous solution, are called monoacid bases.

Examples

NaOH, KOH, NH_4OH are monoacid bases because these bases give only one hydroxyl ion when dissociated in an aqueous medium.

Chemical Equations

$$NaOH_{(aq)} \xrightarrow{water} Na^+_{(aq)} + OH^-_{(aq)}$$

$$KOH_{(aq)} \xrightarrow{water} K^+_{(aq)} + OH^-_{(aq)}$$

As these bases give only one hydroxylOH^-in aqueous medium, therefore these bases are known as mono-acid bases.

ii. Polyacid bases

Those bases, which produce more than one hydroxyl ion (OH^-) per molecule in aqueous solution, are called polyacid bases.

It is further divide into two types i.e.

a. Di-acid bases

Those bases, which produce two hydroxyl ions(OH^-) per molecule in aqueous solution, are called Di-acid bases.

Examples

$Ca(OH)_2$, $Ba(OH)_2$ etc., are di-acid bases because

these bases give more than two hydroxyl ions OH^- when dissociated in an aqueous medium.

Chemical Equations

$$Ca(OH)_{2\,(aq)} \xrightarrow{water} Ca^{++}_{(aq)} + 2OH^-_{(aq)}$$

$$Ba(OH)_{2\,(aq)} \xrightarrow{water} Ba^{++}_{(aq)} + 2OH^-_{(aq)}$$

b. Tri- acid Bases

Those bases, which produce three hydroxyl ions(OH^-) per molecule in aqueous solution, are called tri-acid bases.

Example: $Fe(OH)_3$

Chemical Equations

$$Fe(OH)_{3\,(aq)} \xrightarrow{water} Fe^{3+}_{(aq)} + 3OH^-_{(aq)}$$

As these bases give more than one hydroxyl OH^- in aqueous medium, therefore these bases are collectively known as poly-acid bases.

Q.10 Define strong and weak acids. Give examples.

Ans. Strong Acids

Those acids, which ionize completely in aqueous medium and give higher concentration of hydrogen ions (H^+), are called strong acids. All strong acids are strong electrolytes. Electrolytes are those substances which can dissociate into positive and negative ions in aqueous medium and which can conduct electricity in molten form.

Examples

Examples of strong acids are

Hydrochloric acid	HCl
Sulfuric acid	H_2SO_4
Nitric acid	HNO_3
Perchloric acid	$HClO_4$

The above acids dissociate completely in aqueous medium.

Weak Acids

Those acids, which do not dissociate completely in aqueous medium and give lower concentration of H^+ ions, are called weak acids. All weak acids are weak electrolytes.

Examples

Acetic Acid	CH_3COOH
Nitrous acid	HNO_2
Sulphurous acid	H_2SO_3
Carbonic acid	H_2CO_3
Phosphoric acid	H_3PO_4

These acids dissociate to lesser extent when added to aqueous medium.

Q.11 Define strong bases and weak bases. Give examples.

Ans. **Strong Bases**

Those bases, which ionize completely in aqueous medium and give higher concentration of Hydroxyl ions (OH^-), are called strong bases. All strong bases are strong electrolytes. Electrolytes are those substances which can dissociate into positive and negative ions in aqueous medium and which can conduct electricity in molten form.

Examples

Examples of strong bases are

Sodium Hydroxide	$NaOH$
Potassium hydroxide	KOH
Lithium Hydroxide	$LiOH$

Weak Bases

Those bases, which do not, ionize completely in

aqueous medium, and give lesser concentration of Hydroxyl ions (OH^-), are called weak bases. All weak bases are weak electrolytes.

Examples

Examples of weak bases are

Ammonium Hydroxide	NH_4OH
Calcium hydroxide	$Ca(OH)_2$
Aluminum Hydroxide	$Al(OH)_3$

Q.12 Explain the self ionization/auto ionization/auto-dissociation of water. OR

What do you mean by the auto protolysis of water?

Ans. **Self-Ionization/Auto-Ionization of water**

Definition

The ionization reaction in which two water molecules dissociate into hydronium ion H_3O^+ and hydroxyl ion OH^- is called auto-ionization of water.

Explanation:

In Auto-ionization of water, water molecule dissociate into H^+ and OH^- ions. H^+ion accept a lone pair of electrons from another water molecule and thus exist in the form of Hydronium ion H_3O^+in water.

Chemical Reaction

Consider the following chemical reaction

$$\underset{\text{Proton acceptor}}{H_2O_{(l)}} + \underset{\text{Proton donor}}{H_2O_{(l)}} \rightleftharpoons \underset{\text{Conjugate acid}}{H_3O^+_{(aq)}} + \underset{\text{Conjugate base}}{OH^-_{(aq)}}$$

Now consider the dissociation of only one water molecule into H^+ and OH^- at 25 ^0C

$$H_2O_{(l)} \rightleftharpoons H^+_{(aq)} + OH^-_{(aq)}$$

The K_c expression may be written as

$K_c = \frac{[H]^+[OH]^-}{[H_2O]}$ (where [] = concentration)

Re-arranging the equation

$K_c [H_2O] = [H^+][OH^-]$

As we know that the concentration of water molecule is constant,therefore we can write

$K_c [H_2O] = Kw$ (constant × constant = constant)

Where "K_w" is the ionization constant of water and its value is constant at constant temperature.

It is determined experimentally that at 25^0C out of 10^{14} molecules of water, only one water molecule dissociates into H^+ and OH^-. Thus the molar concentration of the product of H^+ and OH^- will be

$$[H^+][OH^-] = \frac{1}{10^{14}}$$

Or $[H^+][OH^-] = 1\times 10^{-14}$

As

$$[H^+] = [OH]$$

Therefore

$$[H^+][H^+] = 1\times 10^{-14}$$

$$[H^+]^2 = 1\times 10^{-14}$$

Taking square root on both sides

$$\sqrt{[H+]^2} = \sqrt{1 \times 10^{-14}}$$

$$[H^+] = 1\times 10^{-7}$$

Similarly $[OH^-] = 1\times 10^{-7}$

And

$K_w = [H^+][OH^-] = 1\times 10^{-14}$

So, we can write that the value of ionization constant of water i.e. K_w is 1×10^{-14} at 25 ^{0}C.

Q.13 Define pH and pOH. Explain your answer.

Ans. pH:

pH of a solution may be defined as the negative logarithm of the molar concentration of hydrogen ions $[H^+]$

The pH of a solution can be expressed mathematically as;

$$pH = -\log [H^+]$$

pOH:

pOH of a solution may be defined as the negative logarithm of the molar concentration of hydroxyl ion $[OH^-]$ and can be expressed as;

$$pOH = -\log [OH^+]$$

Explanation

In 1909 Soren Peter Lauritz Sorenson introduced a scale for measurement of strength of acids and bases i.e. pH and pOH. The letter "p" stands for "potenz" which means "the potential to be."

The letter small "p" also represents negative logarithm in mathematics. As the concentration terms, are very small values and most often in decimal form therefore the concept of pH and pOH offer a logarithmic form of the concentration terms and thus make it easy to deal with the very small values of concentration.

The pH scale shows the extent of acidity or basicity of a solution. Based on pH, we have three types of solutions i.e. acidic, basic and neutral.

- Solutions having pH above 7 are basic in nature
- Solutions having pH below 7 are acidic in nature.

- Solutions having pH equal to 7 are neutral i.e. they are neither acids nor bases.

Following table shows a relation in between the concentration and pH value.

Concentration ofHydrogen ion $[H^+]$	pH value	Concentration of Hydroxyl ion $[OH^-]$	pOH
1×10^{0}	0	1×10^{0}	0
1×10^{-1}	1	1×10^{-1}	1
1×10^{-2}	2	1×10^{-2}	2
1×10^{-3}	3	1×10^{-3}	3
1×10^{-4}	4	1×10^{-4}	4
1×10^{-5}	5	1×10^{-5}	5
1×10^{-6}	6	1×10^{-6}	6
1×10^{-7}	7	1×10^{-7}	7
1×10^{-8}	8	1×10^{-8}	8
1×10^{-9}	9	1×10^{-9}	9
1×10^{-10}	10	1×10^{-10}	10
1×10^{-11}	11	1×10^{-11}	11
1×10^{-12}	12	1×10^{-12}	12
1×10^{-13}	13	1×10^{-13}	13
1×10^{-14}	14	1×10^{-14}	14

It is obvious from the table that

- As the concentration of hydrogen ion $[H^+]$ increases, the solution becomes more acidic and the pH decreases.
- As the concentration of hydrogen ion $[H^+]$ decreases, the solution becomes more basic and the pH increases.
- As the concentration of hydroxyl ion $[OH^-]$ increases,

the solution becomes more basic and the pOH decreases.

- As the concentration of hydroxyl ion $[OH^-]$ decreases, the solution becomes more acidic and the pOH increases.

Q.14 Calculate the pH and pOH of water.

Ans. **pH of water**

As the pH of a solution can be expressed as

$pH = -\log [H^+]$

We know that the concentration of H^+ at 25°C is 1×10^{-7}

Putting values

$pH = -\log [1\times10^{-7}]$

$pH = -\log 1 + -\log 10^{-7}$ $\quad \log(a.b) = \log a + \log b$

As $\log (1) = 0$

Therefore, $pH = 0 + -\log10^{-7}$

$pH = -(-7\log 10)$ $\quad \log(a)^n = n \log(a)$

$pH = 7\ (1)$ $\quad \log 10 = 1$

Thus, pH of water at 25 °C = 7

pOH of water

As the pOH of a solution can be expressed as

$pOH = -\log [OH^-]$

We know that the concentration of OH^- at 25°C is 1×10^{-7}

Putting values

$pOH = -\log [1\times10^{-7}]$

$pOH = -\log 1 + -\log 10^{-7}$ $\quad \log(a.b) = \log a + \log b$

As log (1) = 0

Therefore, pOH $= 0 + -\log 10^{-7}$

pOH $= -(-7\log 10)$ $\log(a)^n = n\log(a)$

pOH $= 7\ (1)$ $\log 10 = 1$

Thus, pOH of water at 25 °C = 7

Q.14 Prove that pH + pOH = 14

Ans. Consider the auto-ionization of water i.e.

$K_w = [H^+][OH^-]$

Or $[H^+][OH^-] = K_w$ ------------1

We know that the value of $K_w = 1\times10^{-14}$ at 25°C.

Putting value of K_w in equation 1

$[H^+][OH^-] = 1\times10^{-14}$

Taking negative log of both sides

$-\log([H^+][OH^-]) = -\log(1\times10^{-14})$----------2

We know that log (a.b) = log a + log b,

Thus equation 2 becomes

$(-\log[H^+]) + (-\log[OH^-]) = -\log(1) + -\log(10^{-14})$ ---3

As $-\log[H^+] = pH$ and $-\log[OH^-] = pOH$

Therefore equation 3 becomes

$pH + pOH = 0 + -\log(10^{-14})$ because log 1 = 0

As $\log a^n = n\log a$ therefore we can write the equation as

$pH + pOH = 0 + -(-14\log 10)$

We know that, log 10 = 1 therefore

$pH + pOH = 0 + 14\ (1)$

$pH + pOH = 14$

Hence proved that pH + pOH = 14

Q.16 Describe the types of solutions on the bases of pH or pOH.

Ans. There are three types ofsolutions on the bases of pH or pOH.

<u>Acidic solutions</u>

Those solutions in which the concentration of hydrogen ions(H^+)is greater than that of hydroxyl ions (OH^-)are called acidic solutions.

OR

Those solutions in which the concentration of hydrogen ions (H^+) is greater than 1×10^{-7}Mat 25°C are called acidic solutions.

<u>Basic Solutions</u>

Those solutions in which the concentration of hydroxide ions (OH^-) is greater than that of hydrogen ions(H^+)are called basic solutions. OR

Those solutions in which the concentration of hydroxide ions (OH^-)are greater than 1×10^{-7}M at 25 ^{0}C are called basic solutions.

<u>Neutral Solutions</u>

Those solutions in which the concentration of hydrogen ions (H^+) are equal to that of Hydroxyl ions (OH^-) are called neutral solutions. OR

Those solutions in which the concentration of hydrogen ions (H^+) or Hydroxyl ions (OH^-) are equal to 1×10^{-7} M at 25 ^{0}C are called neutral solutions.

Q.17 Define neutralization reaction. Give examples

Ans. <u>Neutralization Reaction</u>

A chemical reaction in which an acid and base react to form salt and water is called neutralization reaction.

Explanation

Let us consider the chemical reaction of a strong acid like hydrochloric acid (HCl) and a strong base like sodium hydroxide (NaOH) in aqueous medium.The chemical equation for this reaction is given below.

$$NaOH_{(aq)} + HCl_{(aq)} \xrightarrow{water} NaCl_{(aq)} + H_2O_{(l)}$$

If 1 mole of NaOH is present in an aqueous medium, then the dissociation of NaOH into Na^+ and OH^- by Arrhenius concept can be expressed as

$$NaOH_{(aq)} \xrightarrow{water} Na^+_{(aq)} + OH^-_{(aq)}$$

Similarly, if 1 mole of HCl is present in an aqueous medium, then the dissociation of HCl into H^+ and Cl^- by Arrhenius concept can be expressed as

$$HCl_{(aq)} \xrightarrow{water} H^+_{(aq)} + Cl^-_{(aq)}$$

If we mix both of thesesolutions, then the chemical reaction between the dissociated ions of both the species is given below.

$$H^+_{(aq)} + Cl^-_{(aq)} + Na^+_{(aq)} + OH^-_{(aq)} \xrightarrow{water} Na^+Cl^-_{(aq)} + H_2O_{(l)}$$

It is obvious from the above chemical reaction that only H^+ and OH^-react together to form H_2O and $Na^+$and Cl^-remain un-reacted(spectator ions).

The net ionic equation for neutralization reaction is given below.

$$H^+_{(aq)} + OH^-_{(aq)} \xrightarrow{water} H_2O_{(l)}$$

Spectator ions

Ions, which do not participate in a chemical reaction and remain unchanged in a chemical reaction, are called spectator ions. For example Na^+Cl^- in neutralization reaction.

Q.18 What are salts? How salts are prepared?

Ans. **Salts**

The compound which is formed as a result of neutralization reaction of an acid and a base is called salt. A salt comprises of two ions i.e. a cation(positive ion) and anion(negative ion). During neutralization reaction the cation comes from a base and the anion comes from an acid which leads to the formation of a salt.

In other words we can say that a salt consist of a metal ion from a base and a non-metal ion from an acid.

Example

non-metal ion from acid

$$NaOH_{(aq)} + HCl_{(aq)} \longrightarrow Na^{+}Cl^{-}_{(aq)} + H_2O_{(aq)}$$

Metal ion from base Salt

Other metal positive ions are K^{+}, Ag^{+}, Mg^{++}, Ca^{++}

Other non-metal negative ions are Br^{-}, SO_4^{-2}, PO_4^{-3}

Preparation of salts

On the bases of the solubility of salts in an aqueous medium, we have two types of salts i.e.

- Soluble salts
- Insoluble salts

Soluble and insoluble salts are prepared by different methods.

Preparation of soluble salts

Soluble salts are usually prepared in water. After the formation of a soluble salt, excess of water is removed by evaporation or crystallization process. Soluble salts are prepared by four methods. Each method is discussed below.

i. **Metal- Acid action (Direct displacement method)**

In this method, a reactive metal is made to react with

an acid. As a result, salt and hydrogen gas are produced. The salt is left behind, and hydrogen gas is evaporated. This method is also used for the preparation of hydrogen gas in the laboratory.

A balanced chemical equation of this method is given below.

$$2HCl_{(aq)} + Mg_{(s)} \longrightarrow MgCl_{2(aq)} + H_{2(g)}$$

Other metals like Calcium, Zinc etc also react with HCl to form salt and H_2 gas.

$$2HCl_{(aq)} + Ca_{(s)} \longrightarrow CaCl_{2(aq)} + H_{2(g)}$$

ii. **Acid-Base reaction (Neutralization method)**

In this method, an acid reacts with a base which produces salt and water. The acid and base neutralize the effect of each other therefore this reaction is called neutralization reaction. The chemical equation is given as under

$$HCl_{(aq)} + NaOH_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(aq)}$$

iii. **Acid and Metallic oxide action**

Bases like metallic oxides react with dilute acids to form salt and water. Metallic oxide like calcium oxide (CaO) when react with acid like H_2SO_4 produces $CaSO_4$(a salt) and water.

$$H_2SO_{4(aq)} + CaO_{(aq)} \longrightarrow CaSO_{4(aq)} + H_2O_{(l)}$$

$$H_2SO_{4(aq)} + CuO_{(aq)} \longrightarrow CuSO_{4(aq)} + H_2O_{(l)}$$

iv. **Acid and carbonate reaction**

In this method dilute acids are made to react with carbonates like sodium carbonate Na_2CO_3 and bicarbonates like sodium bicarbonates $NaHCO_3$which produce salt, water and Carbon dioxide(CO_2).

The chemical equations are given below

$$2HCl_{(aq)} + Na_2CO_{3(aq)} \longrightarrow 2NaCl_{(aq)} + H_2O_{(aq)} + CO_{2(g)}$$

$$HCl_{(aq)} + NaHCO_{3(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(aq)} + CO_{2(g)}$$

Preparation of insoluble salts

Insoluble salts are prepared by precipitation method.

Precipitation Method

In this method, insoluble salts are prepared from a solution of soluble salts. Solution of soluble salts is mixed with one another and as a result insoluble salt is formed. In this reaction two types of salts are formed, one is soluble and the other is insoluble. The insoluble salt is precipitated.

$$AgNO_{3(aq)} + NaCl_{(aq)} \longrightarrow AgCl_{(S)} + NaNO_{3(aq)}$$

$$Na_2CO_{3(aq)} + CuSO_{4(aq)} \longrightarrow CuCO_{3(s)} + Na_2SO_{4(aq)}$$

Q.19 Describe the types of salts.

Ans. The common types of salts are:

i. **Normal salts (Neutral salts)**

The salt which is formed by the neutralization reaction of a strong acid with a strong base is called neutral salt.

pH of Neutral Salt

The pH of neutral salt is equal to 7.

Examples

Examples of normal salts are Sodium Chloride (NaCl) , Potassium Chloride (KCl), Sodium Nitrate ($NaNO_3$), Potassium Sulphate (K_2SO_4) etc.

Chemical Reactions

The neutralization reaction of Sodium Hydroxide (NaOH) and Hydrochloric Acid (HCl) produces a neutral salt Sodium Chloride (NaCl)because NaOH is a strong base and HCl is a strong acid.

$$NaOH_{(aq)} + HCl_{(aq)} \xrightarrow{water} NaCl_{(aq)} + H_2O_{(l)}$$

Similarly for KCl, the reaction will be

$$KOH_{(aq)} + HCl_{(aq)} \xrightarrow{water} KCl_{(aq)} + H_2O_{(l)}$$

For $NaNO_3$, the reaction will be

$$NaOH_{(aq)} + HNO_{3(aq)} \xrightarrow{water} NaNO_{3(aq)} + H_2O_{(l)}$$

ii. **Acidic Salts**

The salt which is formed by the reaction of strong acid with a weak base is called acidic salt.

pH of Acidic Salt

The pH of acidic salt is less than 7.

Example

Examples of Acidic salts are Ammonium Chloride (NH_4Cl) , Ammonium Nitrate (NH_4NO_3), Ammonium Sulphate ($(NH_4)_2SO_4$)

Chemical Reaction

The reaction of ammonium hydroxide (NH_4OH) and Hydrochloric acid (HCl) Produces and acidic salt like Ammonium chloride (NH_4Cl). The chemical reaction is given below.

$$NH_4OH_{(aq)} + HCl_{(aq)} \xrightarrow{water} NH_4Cl_{(aq)} + H_2O_{(aq)}$$

Similarly for NH_4NO_3 the reaction will be

$$NH_4OH_{(aq)} + HNO_{3(aq)} \xrightarrow{water} NH_4NO_{3(aq)} + H_2O_{(aq)}$$

iii. **Basic salts**

The salt which is formed by the reaction of a strong base with a week acid is called basic salt.

pH of Basic Salt

The pH of basic salt is greater than 7.

Examples

Examples of basic salts areSodium carbonate

(Na_2CO_3), Sodium acetate (CH_3COONa), Calcium Carbonate($CaCO_3$) etc

Chemical Reaction

The reaction of a strong base like sodium hydroxide (NaOH) and weak acid Carbonic Acid(H_2CO_3) produces a basic salt like Sodium carbonate (Na_2CO_3).

The reaction is given as under,

$$2NaOH(aq) + H_2CO_3 \xrightarrow{water} Na_2CO_{3(aq)} + 2H_2O_{(aq)}$$

Similarly in case of Sodium acetate (CH_3COONa) the reaction will be,

$$NaOH(aq) + CH_3COOH_{(aq)} \xrightarrow{water} CH_3COONa_{(aq)} + H_2O_{(aq)}$$

iv. Double salts

Those salts, which are formed as a result of crystallization of an equi-molar saturated solution of two normal salts are called double salts. These salts are a combination of two normal salts which are mixed in equal molar proportion. Both the salts do not affect the properties of one another and both the salts retain their properties.

Examples

Potash Alum	$K_2SO_4.Al_2(SO_4)_3.24H_2O$
Ferric Alum	$NH_4Fe(SO_4)_2.12H_2O$
Mohr'salt	$(NH_4)_2Fe(SO_4)_2.6H_2O$

Q.20 Write uses of salts.

Ans. Uses of Salts

We use a large variety of salts in our daily life like Sodium Chloride is used as Table salt, Potash Alum is used as germicides, Sodium carbonate is used in detergents etc.Different salts are used in different ways. The name and uses of some common salts are given below.

i. Sodium Chloride

Some of the uses of sodium chloride are given below;

- It is used for taste improvement in food.
- It is used as preservatives for foods like meat etc.
- It is used as raw material for the extraction of sodium metal.
- It is used as raw material for the preparation of NaOH.
- It is used as raw material for the preparation of sodium carbonate (Na_2CO_3).

ii. Sodium Carbonate (Na_2CO_3)

It is also known as Soda Ash or Washing soda because it is commonly used as cleaning agent in surfactants and detergents.

Important uses of sodium carbonate are described as under;

- It is used in laundries as cleaning agent and water softener.
- It is used as raw material in glass industries.
- It is used in paper industries.
- It is used in petroleum refining industries.
- It is used in leather industries etc.

iii. Sodium Sulphate (Na_2SO_4)

Important uses of sodium sulphate are the following;

- It is used in paper industries.
- It is used in glass industries.
- It is used in surfactants anddetergents.
- It is used for drying organic liquids.

iv. Sodium hydrogen carbonate or sodium bicarbonate

Sodium bicarbonate is also known as Baking soda because it is most commonly used in baking i.e. preparation of cakes and confectionaries (common name "Halwa").

Other uses of sodium bicarbonate are:

- It is used as ant-acid for relieving heartburn and acid indigestion.
- It is used in tooth pastes
- It is used in baking industries
- It may be used as mouthwash.

v. Potassium nitrate (KNO_3)

Uses of potassium nitrate are:

- It is used in fertilizers as a source of nitrogen and potassium.
- It is used for the manufacturing of flint glass.
- It is used in some toothpaste for sensitive teeth.
- It is used as electrolyte in a salt bridge.

vi. Potash Alum ($K_2SO_4.Al_2(SO_4)_3.24H_2O$)

It is also known as Alum. It is commonly available in the market and is generally known as "Phatakni" (in urdu).Many barbers use it for clotting blood.

Some of the uses of potash alum are described below

- It is used for removing suspended impurities from water.
- It is used in textile industries.
- It is used as medicine.
- It is used as blood coagulant.

vii. Calcium sulphate ($CaSO_4.2H_2O$)

It is commonly known as gypsum. Uses of calcium sulphate are given below.

- It is used as fertilizer.
- It is used in preparation of plaster of Paris.
- It is used in cement industries.
- It is used as moisture indicator.
- It prevents water logging ("seem" and "thoor" in urdu)

viii. Calcium carbonate ($CaCO_3$)

Its common name is limestone and it is found in rocks.Some of the uses of calcium carbonates are:

- It is used as calcium supplement.
- It is used as an ant acid.
- It is used in the preparation of cement.
- It is used in ceramic industries.
- It is used in chalk and marble industries.

ix. Magnesium sulphate($MgSO_4.7H_2O$)

It is commonly known as Epsom salt. Uses of Epsom salt are

- It is used as ant-acid.
- It is used in dye industries.
- It is used as laxatives. (Laxatives are medicines used for relieving constipation)
- It is used for improving crops growth.
- It is used for fulfilling magnesium deficiency of soil.

x. Copper Sulphate ($CuSO_4.5H_2O$)

It is also known as Blue Vitriol (neela thotha in urdu).

Important uses of copper sulphate are the following:

- It is used in the electroplating of copper.
- It is used for killing algae in water reservoirs.
- It is used in agricultural spray.
- It is used as fungicides.
- It is used as herbicides.

Name and chemical formula of some acids

Name	Formula	Name	Formula
Hydrochloric acid	HCl	Formic acid	$HCOOH$
Hydrobromic acid	HBr	Acetic acid	CH_3COOH
Nitric acid	HNO_3	Propanoic acid	C_2H_5COOH
Sulphuric acid	H_2SO_4	Phosphoric Acid	H_3PO_4

Name and chemical formula of some bases

Name	Formula	Name	Formula
Sodium Hydroxide	$NaOH$	Aluminum hydroxide	$Al(OH)_3$
Potassium hydroxide	KOH	Ferric hydroxide	$Fe(OH)_3$
Calcium hydroxide	$Ca(OH)_2$	Ammonium hydroxide	NH_4OH
Magnesium hydroxide	$Mg(OH)_2$	Barium hydroxide	$Ba(OH)_2$

EXAMPLES

Example: 1

Which of the following are Arrhenius acids and bases?

a) $Ca(OH)_2$ b) HNO_3 c) $NaOH$

d) H_2SO_4 e) KOH

Ans. Arrhenius Acids

HNO_3 and H_2SO_4

Arrhenius Bases

$Ca(OH)_2$, NaOH, KOH

Example: 2

Calculate the pH and pOH of 0.001 M solution of nitric acid HNO_3.

Given

$$[H^+] = 0.001M = \frac{1}{1000} = \frac{1}{10^3} = 10^{-3}M$$

Required

pH = ?

pOH = ?

Solution

First, we shallwrite the balance chemical equation i.e.

$$HNO_{3(aq)} \xrightarrow{water} H^+_{(aq)} + NO_3^-{}_{(aq)}$$

$10^{-3}M$ $\quad$ $10^{-3}M$

We know that,

$pH = -\log [H^+]$

Putting value of concentration of H^+ we get

$pH = -\log(10^{-3})$

$pH = -(-3\log 10)$ (because $\log a^n = n \log a$)

$pH = +3\ (1)$ (because $\log 10 = 1$)

$pH = 3$

Now for finding pOH we will use the formula:

$pH + pOH = 14$

Putting the value of pH in this equation

$3 + pOH = 14$

$pOH = 14 - 3$

pOH =11

Result

pH= 3, pOH =11

2. **Calculate the pOH and pH of 0.01M solution of potassium hydroxide (KOH)**

Given

$$[OH^-] = 0.01M = \frac{1}{100} = \frac{1}{10^2} = 10^{-2}M$$

Required

pOH=?

pH =?

Solution

First, we shallwrite the balance chemical equation i.e

$KOH_{(aq)} \xrightarrow{water} K^+_{(aq)} + OH^-_{(aq)}$

$10^{-2}M$ $10^{-2}M$

We know that,

$pOH = -\log [OH^-]$

Putting value of concentration of OH^- we get

$pOH = -\log (10^{-2})$

$pOH = -(-2\log 10)$ (because $\log a^n = n \log a$)

$pOH = +2(1)$ (because $\log 10 = 1$)

pOH= 2

Now for finding pH we will use the formula:

pH + pOH = 14

Putting the value of pOH in this equation

pH+2= 14

pH =14 – 2

Result

pH=12, pOH = 2

EXERCISE

A. Choose the correct option.

1. According to Arrhenius concept, which of the following is not an acid,

   a. HCl　　b. H_2SO_4

   c. CO_2　　d. HNO_3

2. $AlCl_3$ is an acid according to the,

   a. Arrehnius　　b. Lowry and Bronsted

   c. Lewis　　d. All of these

3. Which of the following is a Lewis base,

   a. HCl　　b. $AlCl_3$

   c. BF_3　　d. F^-

4. Neutral Solution has a pH value of,

   a. 3　　b. 5

   c. 7　　d. 14

5. The pOH of 0.001M solution of nitric acid is,

   a. 0.001　　b. 10.0

   c. 11　　d. 14

6. When a strong base and weak acid react, the only products are,

   a. Neutral salt and water　　b. Basic salt and water

   c. Acidic salt and water　　d. Acidic, basic salt and water

7. NH_3 is a base according to,
   a. Arrhenius b. Lowery and Bronsted
   c. Lewis d. Both b & c
8. Which one of the following is a basic salt,
   a. KCl b. NaCl
   c. Pb(OH)Cl d. $KHSO_4$
9. Those bases which are soluble in water are called
   a. Acids b. Alkalis
   c. Salts d. Amphoteric substances
10. The example of weak acid is,
   a. HNO_3 b. CH_3COOH
   c. HCl d. H_2SO_4

ANSWERS:

1	c	2	c	3	d	4	c	5	c
6	b	7	d	8	c	9	b	10	b

B. Write short answers to the following questions.

Q.1 When a clear liquid is placed in a beaker. How will you identify it as an acid, base or neutral (water)?

Ans. A litmus test can tell us that whether the clear liquid placed in a beaker is acid, base or a neutral liquid. The following procedure is used for carrying out a litmus test.

For acid:

Take a blue litmus paper and dip it in the liquid. If the color of the blue litmus paper changes from blue to red then the liquid is acid.

For Base:

Take a red litmus paper and dip it in the clear liquid if the color of the red litmus paper turns blue then the liquid is a base.

For neutral:

If the liquid has no effect on both the litmus papers then the liquid is neither an acid nor a base rather it is a neutral liquid (water).

Q.2 Justify H^+ ion as a Lewis acid.

Ans. According to Lewis those species can act as an acid, which

- can accept a pair of electron(electrophile)
- have less than eight electrons in the valence shell of central atom
- are positive ions or electron deficient specie

All of the above characteristics are present in H^+ ion therefore we can say that H^+ is a Lewis acid.

Q.3 Distinguish strong acids from weak acids? Give two examples.

Ans. See Question 10

Q.4 Compare the physical properties of acids and bases.

Ans. See Question 2

Q.5 A carbonated drink has $[H^+]=3.2\times10^{-3}$ M, Classify the drink as neutral, acidic or basic with reason.

Ans. For classifying the drink as neutral, acidic or basic we need to calculate the pH of the drink first.

- If the value of pH is greater than 7 then drink is basic
- If the value of pH is less than 7 then the drink is acidic

- If the value of pH is equal to 7 then the drink is neutral

Calculation of pH

Given Data;

$[H^+] = 3.2 \times 10^{-3}$ M

Solution

We know that

$pH = -\log [H^+]$

putting values

$pH = -\log (3.2 \times 10^{-3})$

Applying log

$pH = (-\log 3.2) + (-\log 10^{-3})$

because, $\log(a.b) = \log a + \log b$

$pH = -\log 3.2 + \{-(-3\log 10)\}$

$pH = -0.50 + (+3 \times 1)$ As $\log 10 = 1$

$pH = -0.50 + 3$

Result

pH =2.5

Since, the carbonated drink is having a pH of 2.5, which is less than 7 so we can say that: the drink is acidic

Q.6 Write the name of acid present in Apple, Grape juice, Lemon juice and Sour milk.

Ans. See Question 1

Q.7 What determines the strength of a base? Give one example each, of solutions that are strongly and weakly basic.

Ans. See Question 11

Q.8. Calculate the pH and pOH of 0.5 M solution of HCl.

Ans.

Given

$[H^+] = 0.5\,M$

Required

pH=?

pOH =?

Solution

First, we shallwrite the balance chemical equation i.e.

$$HCl_{(aq)} \xrightarrow{water} H^+_{(aq)} + Cl^-_{(aq)}$$

0.50M 0.50M

We know that,

$pH = -\log [H^+]$

Putting value of concentration of H^+we get

$pH = -\log (0.50)$

pH= 0.301

Now for finding pOH we will use the formula:

$pH + pOH = 14$

Putting the value of pH in this equation

$0.301 + pOH = 14$

$pOH = 14 - 0.301$

pOH = 13.69

Result

pH=0.301, pOH = 13.69

Q.9 Calculate the pOH of 0.005M sulphuric acid (H_2SO_4).

Ans.

Given

$[H^+] = 0.005M$

Required

$pOH = ?$

Solution

First, we shallwrite the balance chemical equation i.e

$H_2SO_{4(aq)} \xrightarrow{water} 2H^+_{(aq)} + SO_4^{-2}{}_{(aq)}$

0.005 M 2(0.005) = 0.01M

As H_2SO_4 is a di-protic acid and it gives two protons per molecule.

Therefore, we will multiply the concentration term by 2 i.e.

$[H^+] = 2(0.005)M = 0.01M$

Converting the concentration to exponential form

$[H^+] = 0.01M = 10^{-2}M$

We know that,

$pH = -\log [H^+]$

Putting value of concentration of H^+ we get

$pH = -\log (10^{-2})$

$pH = -(-2\log 10)$ (because $\log a^n = n \log a$)

$pH = +2 (1)$ (because $\log 10 = 1$)

pH = 2

Now for finding pOH we will use the formula:

$pH + pOH = 14$

Putting the value of pH in this equation

$2 + pOH = 14$

$pOH = 14 - 2$

$pOH = 12$

Result

$pH = 2$

$pOH = 12$

Note: The Answer given in the book is wrong

Because, if the concentration units are given in, Molar forms then

For di-protic acid the concentration term must be multiplied by 2

For tri-protic acid the concentration term must be multiplied by 3

Q.10 Calculate the pH of 0.2M solution of NaOH.

Ans.

Given

$[OH^-] = 0.2\ M$

Required

$pH = ?$

Solution

First, we shall write the balance chemical equation i.e.

$NaOH_{(aq)} \xrightarrow{water} Na^+_{(aq)} + OH^-_{(aq)}$

0.2M 0.2M

We know that,

$pOH = -\log [OH^-]$

Putting value of concentration of OH^- we get

pOH = –log (0.2)

pOH= 0.70

Now for finding pH we will use the formula:

pH + pOH = 14

Putting the value of pOH in this equation

0.70+pH = 14

pH=14 – 0.70

pH =13.30

Result

pOH= 0.70

pH =13.30

C. Write detailed answers to the following questions.

Q.1 a) What is salt?

Ans. See Question 18

b) Write down the different types of salts with examples.

Ans. See Question 19

Q.2a) Define auto- ionization of water. How can you find the pH of water?

Ans. See Question 12 and 14

b) Why some acids are called monoprotic, diprotic and polyprotic acids. Explain your answer with suitable examples.

Ans. See Question 9

Q.3 a) Discuss the concept of Lewis acids and bases with examples.

Ans. See Question 7

b) Give the Bronsted-Lowry definition of acids and bases. Write equations that explain the definition.

Ans. See Question 5

Q.4 Below are two equations showing how two alkalis react with water.

$$NaOH_{(aq)} \rightleftharpoons Na^{+}_{(aq)} + OH^{-}_{(aq)}$$

$$NH_{3(aq)} \rightleftharpoons NH_4^{+}{}_{(aq)} + OH^{-}_{(aq)}$$

a) Name both the alkalis.

b) Which is classified as weak alkali and why?

c) What is the pH of each alkali?

Ans.

a) Name of Alkalis

- NaOH Sodium Hydroxide
- NH_3 Ammonia

b) NH_3 is a weak alkali because it does not dissociate completely.

c) The pH of NaOH is 13 and pH of NH_3 is 11.6

Q.5a) Write the balance neutralization reaction of

i. **Strong acid and strong base**

ii. **Strong acid and weak base**

iii. **Weak acid and strong base**

iv. **Weak acid and weak base**

Ans.

i. <u>Strong acid and strong base</u>

$$HCl_{(aq)} + NaOH_{(aq)} \rightleftharpoons Na^{+}Cl^{-}{}_{(aq)} + H_2O_{(l)}$$

ii. Strong acid and weak base

$$HCl_{(aq)} + NH_4OH_{(aq)} \rightleftharpoons NH_4^{+}Cl^{-}{}_{(aq)} + H_2O_{(l)}$$

iii. **Weak acid and strong base**

$$CH_3COOH_{(aq)} + NaOH_{(aq)} \rightleftharpoons CH3COO^-Na^+ + H_2O_{(l)}$$

iv. **Weak acid and weak base**

$$CH_3COOH_{(aq} + NH_4OH_{(aq)} \rightleftharpoons CH3COO^-NH_4^+ + H_2O_{(l)}$$

b) **Define pH and pOH.**

Ans. See Question 13

Q.6 a) According to your understanding which one of the three acid definitions is the broadest? Explain.

Ans. a) **Broadest definition of Acids**

Although, no definition can successfully explain the acidity of every acid but still the Lewis concept of acid and base can be regarded as a broadest concept. According to Lewis, "an acid is specie that can accept a pair of electron". This definition is more general than the definitions presented by Arrhenius and Bronsted-Lowry. Lewis concept is a broadest concept because of the following reasons.

Not limited to Hydrogen atom

Lewis concept is completely independent of hydrogen atom and it can explain the acidity of those species, which do not have hydrogen atom,but they are acidic in naturee.g. $BF_3$is an acid but itdoes not contain Hydrogen atom.This was not explained by Arrhenius.

Not Limited to Proton

It can explain the acidity of those species, which do not donate a proton in a chemical reaction, but still they are acids. This was not explained by Bronsted-Lowry.

Electronic concept

Instead of focusing on H^+ or proton, Lewis focuses on electron pairs. Since all compounds contain electron pairs

therefore the Lewis definition is applicable to a wide range of chemical reactions.

b). Write the uses of three salts.

Ans. See Question 20

Unit 11

Organic Chemistry

Q.1 Define the following:

- Organic Chemistry
- Organic compound
- Hydrocarbons

Ans. Organic Chemistry

It is the branch of chemistry which deals with the study of carbon containing compounds, except oxides of carbon like carbon monoxide, carbon dioxide, carbonates, bicarbonates and carbides.

OR

The chemistry of hydrocarbons and their derivatives is called organic chemistry.

OR

The branch of chemistry, which deals with the study of organic compounds, is called organic chemistry.

Organic Compounds

Hydrocarbons and their derivatives are known as organic compounds.

Hydrocarbons

As the name indicates "hydro" i.e. Hydrogen and "carbon" i.e. Carbon, so;

Those compounds, which are composed of carbon and hydrogen, are called hydrocarbons.

Q.2 Describe the types of formulas in which an organic compound can be represented.

Ans. There are four types of formulas which are commonly used for the representation of organic compounds.

i. Molecular formula

The formula which shows the actual number of atoms present in a molecule of an organic compound is called the molecular formula.

Example

The molecular formula of methane is CH_4 and that of ethane is C_2H_6. It shows that:

- Methane contains one carbon atom and four hydrogen atoms.
- Ethane contains two carbon atoms and six hydrogen atoms.

ii. Structural Formula

The formula, which shows the arrangement of different atoms of different elements around the carbon atom present in a molecule of a compound, is called structural formula.

Structural formula of an organic compound gives the following information:

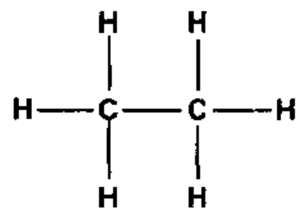
- Number of atoms in a molecule
- Bonding arrangement of the atoms
- Types of atoms in a molecule

In a structural formula:

❖ Single bond is represented by a single line(–)
❖ Double bond is represented by double lines(=)
❖ Triple bond is represented by triple lines (≡)

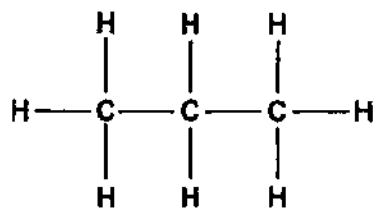
Example:

Structural formula of ethane



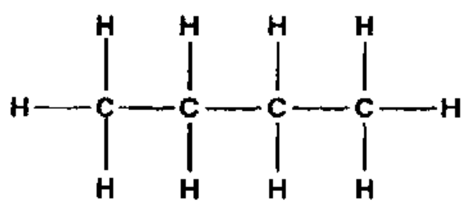
Ethane

Structural formula propane



n-Propane

Structural formula of butane



n-Butane

iii. Condensed formula

The formula in which the groups of atoms are shown in order of a structural formula but without bonds and dashes is called condensed formula.

A true condensed formula is written on a single line without any branching above or below it.

The condensed formula shows

- the symbol of every central atom

- atoms or group of atoms attached to the central atom

Example:

Condensed formula of pentane $CH_3(CH_2)_3CH_3$

Condensed formula of hexane $CH_3(CH_2)_4CH_3$

Condensed formula of heptane $CH_3(CH_2)_5CH_3$

iv. Dot and Cross Formula

The structural formula of a compound in which electrons are shown as dots and cross between different bondedatoms in one molecule of a compound is called dot and cross formula.

It is also called electronic formula.

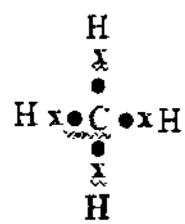
This formula shows:

- The number of atoms in a molecule of a compound
- The types of atoms
- The shared pair of electrons between the two atoms

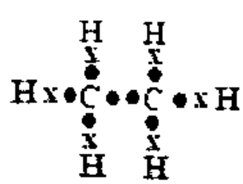
The electron shared by one atom for a covalent bond is represented by a dot (•) and the electron shared by the other atom for a covalent bond is represented by a cross (×).

Examples

Electronic/dot and cross formula of methane



Dot and cross formula of ethane



Q.3 How can you classify the organic compounds?

Ans. On the basis ofcarbon skeleton*, organic compounds are classified into two main groups:

***Carbon skeleton:**

The carbon to carbon bonds (–C–C–) which form chains or cycles in organic compounds is called the carbon skeleton. It is considered the backbone of organic compounds.

1. Open chain or acyclic organic compounds
2. Close chain or cyclic organic compounds

1. Open chain (acyclic organic compounds)

Those organic compounds in which carbon atoms are linked together in an open chain are called open chain or acyclic organic compounds.

These compounds are also known as Aliphatic compounds.

Open chain organic compounds are further classified into:

a. Straight chain organic compounds
b. Branched chain organic compounds

a. Straight chain organic compounds

Those organic compounds, which are in the form of straight chains, are called straight chain organic compounds. A prefix "n-" is written with the name of a straight chain organic compound, which shows that the organic compound is a straight chained and not a branched chained.

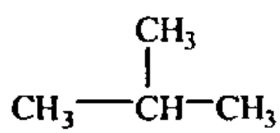
Examples

$CH_3 - CH_2 - CH_3$ (n-propane) $\qquad$ $CH_3 - CH_2 - CH_2 - CH_3$ (n-butane)

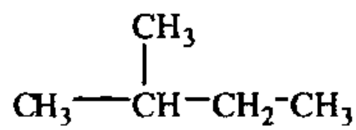
b. Branched chain organic compounds

Those organic compounds, whichare in the form of branched chains rather than in the form of linear/straight sequence are called branched chain organic compounds.In the branched chain organic compounds at least one carbon atom is linked to more than two other carbon atoms. A prefix "iso" is written with the name of a branched chain organic compound for distinguishing it from a straight chain organic compound.

Examples



Isobutane



Isopentane

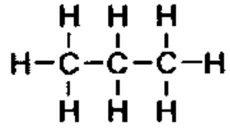
Open chain organic compounds may be saturated or unsaturated depending upon the number of covalent bonds present in them.

- Saturated organic compounds
- Unsaturated organic compounds

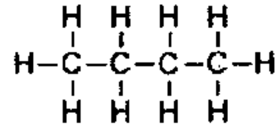
Saturated organic compounds

Those organic compounds in which each carbon atom in a molecule forms four single covalent bonds with other atoms are called saturated organic compounds. In the molecule of a saturated organic compound, all the bonds are single, and no double or triple covalent bond is present. Hydrocarbons that contain single covalent bond are called alkanes.

Examples:



Propane



Butane

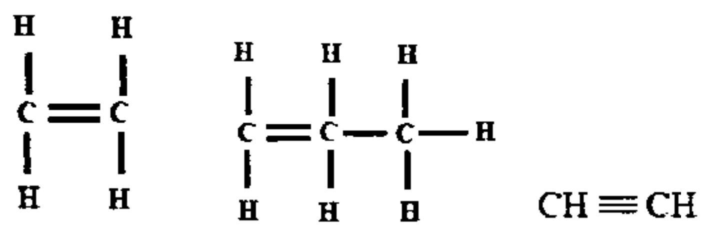
Unsaturated organic compounds

Those organic compounds, in which at least one double bond or triple bond is present are called unsaturated organic compounds.

Unsaturated organic compounds have two types i.e. Alkenes and Alkynes

- Alkenes are those hydrocarbons, which contain at least one double bond.
- Alkynes are those hydrocarbons, which contain at least one triple bond.

Examples:



Ethene Propene Ethyne

2. Close chain/cyclic organic compounds

Those organic compounds in which atoms are connected in the form of a closed chain orrings are called close chain/cyclic organic compounds.

Close chain organic compounds are further classified into

i. Ali-cyclic organic compounds

ii. Aromatic organic compounds

i. Ali-cyclic organic compounds

Organic compounds which are in the form of closed chains or ring but resemble in properties with acyclic organic compounds are called ali-cyclic organic compounds.

OR

Those organic compounds which are both aliphatic and cyclic in nature are called Ali-cyclic organic compounds. The prefix "cyclo" is used while writing the name of an Alicylic organic compound. They differ from aliphatic organic compounds by H_2 e.g. formula of Aliphatic/Acyclic propane is C_3H_8 and that of Cyclopropane is C_3H_6 i.e. cyclopropane has two hydrogen atoms lesser than in propane.

Ali-cyclic organic compounds may be:

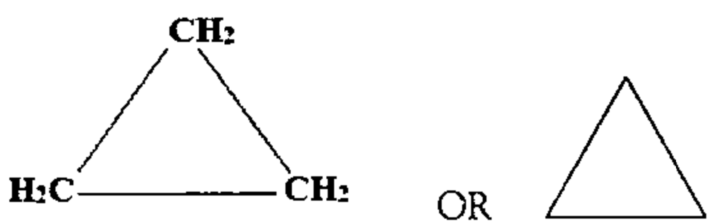
a. Homocyclic organic compounds

b. Heterocyclic organic compounds

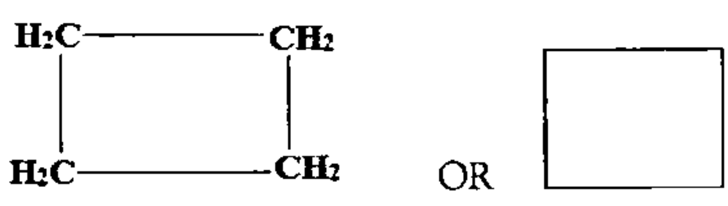
a. <u>Homocyclic organic compounds</u>

Those cyclic organic compounds in which the ring contains carbon atoms only are called homocyclic organic compounds. Homocyclic organic compounds are also known as carbocyclic organic compounds because all the atoms contributing to the ring structure are carbons only.

Examples:



Cyclopropane

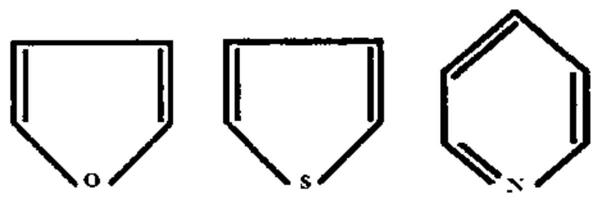


Cyclobutane

b. **Hetero Cyclic organic compounds**

Those cyclic organic compounds in which the atoms forming the ring contain one or more atoms other than carbon are called heterocyclic organic compounds.

Examples:



Furane Thiophene Pyridine

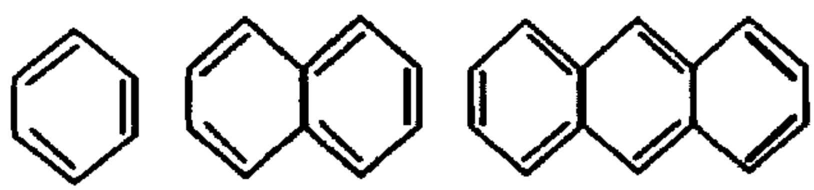
ii. **Aromatic Organic compounds**

There are various properties that distinguish aromatic compounds from Ali-cyclic/Non aromatic compounds. Some characteristic features of the aromatic compounds are:

- They are in the form of closed chain
- They have alternate single and double bonds
- They have a characteristic odour
- They show resemblance to benzene in structure
- They must have $(4n+2)\pi$ electrons. Where n=0,1,2,3......

The above-mentioned characteristics are not enough for determining the aromaticity of a compound, there are certain other conditions that are necessary for a compound to be aromatic.

Example:



Benzene Naphthalene Anthracene

Q.4 Explain magnitude and diversity of organic compounds. Describe the characteristics that make organic compounds a diverse group.

Ans. Organic compounds are a diverse group of compounds. Most of the substances we use in our daily life are organic in nature. Fuel, Petrol, Cloth etc., are organic in nature. The food we eat, the medicine we use all are organic in nature. The factors that are responsible for this diversity of organic compounds are discussed below;

i. Tetra-valent

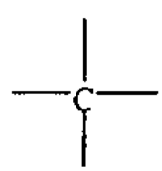
Carbon is tetra-valent because it can form four bonds.

ii. Mode of bonding

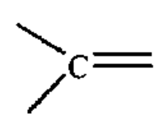
The following modes of bonding are found in the bonding of one carbon atom with the other.

- Four single covalent bond
- Two single and one double bond
- Two double bonds
- One triple bond and one single bond

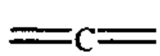
Examples:



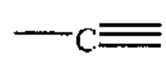
Four single bonds



Two single and one double bond



Two double bonds



one single and one triple bond

iii. Carbon-carbon bonding (Catenation)

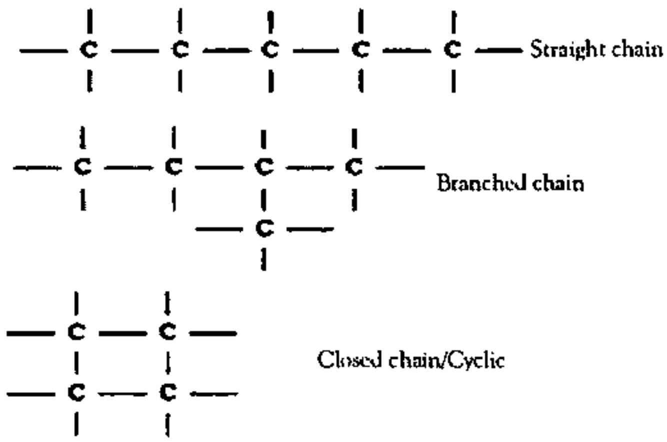
The linkage (bonding) of one carbon atom with

another carbon atom is called catenation.

OR

Self-linkage of carbon atom is called catenation.

Carbon atoms have the ability to form long chains, branched chains, and rings of covalently bonded atoms with each other. This property of carbon also contributes to the diversity of organic compounds.



iv. <u>Bonding with other atoms</u>

Carbon atoms can form bond with other atoms like oxygen, nitrogen, sulphur and halogens. This ability of carbon is also responsible for the diversity of organic compounds.

v. <u>Arrangement of atoms</u>

The bonding arrangement of the atoms makes one compound different from the other compound. Carbon atoms have the ability to arrange in different patterns. This ability is responsible for the differences between properties of two organic compounds. Those organic compounds, which have the same molecular formula but different structural formula,are called isomers. The difference in the structural formula is due to the arrangement of carbon atoms

Examples

Structural formula:	CH_3-O-CH_3	CH_3-CH_2-OH
Molecular formula:	C_2H_6O	C_2H_6O
	Di-methyl ether	Ethyl Alcohol

vi. Strength of covalent bonds of carbon atoms

Carbon atoms form strong covalent bonds with each other and with other atoms like hydrogen, oxygen, sulphur, nitrogen etc. Carbon atom is small in size and in most of the compounds, the shared pair of electrons involved in a chemical bond is strongly held by the nucleus of the carbon atom. This property of carbon also attributes to the diversity among organic compounds.

Q.5 What are the major characteristics of organic compound?

Ans. The characteristics of organic compounds are given below.

i. Composition

Mostly organic compounds are composed of carbon atoms. In some compounds, atoms other than carbon such as oxygen, sulphur, nitrogen etc., are also present.

ii. Covalent nature

Organic compounds are covalent in nature. This means that they have covalent bonds in between the atoms. They are mostly non-polar, and they do not ionize in aqueous solution.

iii. Solubility

As organic compounds are non-polar in nature therefore, they are soluble in non-polar solvents like benzene, ether etc. They are insoluble in polar solvent like water.

iv. Low Melting Point and Boiling Point

The intra-molecular forces in organic compounds are strong but the intermolecular forces among the molecules of organic compounds are weak. Due to these weak intermolecular forces, the molecules of organic compound can be easily separated from each other or in other words, they are volatile in nature. This volatility is responsible for the low melting points and boiling points of organic compounds.

v. Thermal instability

Organic compounds are thermally unstable. They are easily decomposed to smaller molecules by heating.

vi. In-flammability

Organic compounds are highly inflammable. They catch fire when exposed to a flame. They burn in the presence of air and produce carbon dioxide, water and huge amount of heat.Natural gas, diesel and gasoline are organic compounds that are used as fuel. Their combustion produces a large amount of heat, used to power vehicles etc.

vii. Reactivity

Reactions of organic compounds are slower than inorganic reaction because theforces in between the atoms of organic compounds are strong.A proper catalyst and a specific amount of heat are required for their reaction to take place.

viii. Burn with smoky flame

Higher molecules of organic compound burn with smoky flame due to incomplete combustion.

ix. Isomerism

The compounds are said to be isomers of each other if they have the same molecular formula but different structural formula. The existence of such a phenomenon in between the two organic compounds is called isomerism.

x. **Non-ionic character**

Organic compounds have covalent bond in between carbon atoms (C-C) and carbon-hydrogen atoms (C-H). The electro-negativity difference in between Carbon and Hydrogen atom is negligible therefore organic compounds are non-polar in nature that is why they do not get ionized and hence,show non-ionic character.

xi. **Homologous series (similarity in behavior)**

Homologous series is a series of organic compounds in which every successive member is greater by a $-CH_2-$ from the previous member, e.g. methane, ethane, propane are homologues of eachother. Homologues have the same chemical properties due to presence of same functional group.

xii. **Electrical conductivity**

Organic compounds donot have free electrons and they are not in ionized state therefore they are poor conductor of electricity in fused state and in solution forms.

Q.6 Explainin detail the different sources of organic compounds.

Ans. **Sources of organic compounds**

Fossil fuels are the main sources of organic compounds. Fossil fuels comprise of Coal,Petroleum and Natural Gas. Fossil fuel is formed under the surface of earth due to the anaerobic decomposition of plants and animals under high temperature and pressure in millions of years. Organic compounds like proteins are obtained from animals and carbohydrates are obtained from plants. The main sources of organic compounds are described below.

i. **Coal**

- Coal is a brown black solid mass containing carbon as its major constituent.

- Coal is a major source of organic compound.
- Coal is believed to be the remains of trees.
- Coal is formed under high pressure and temperature below the earth surface.
- The bacterio-chemical actions on plants and trees for millions of years convert them into peat.
- Peat is converted to coal on high temperature and pressure.
- Coal is found in mines under the earth surface.

Destructive distillation of coal (Carbonization of Coal)

Heating coal in the absence of air is called destructive distillation of coal or carbonization.

In the destructive distillation of coal, Coal is converted to

- Coal gas
- coke
- coal tar
- Ammonical liquor

These are the sources of organic compounds.

ii. Petroleum

- "Petro" means rock and "oleum" means oil.
- Petroleum is called Rock oil or mineral oil or crude oil or Liquid Gold.
- It is found under the earth along with other impurities.
- It is dark brown in colour and it has an unpleasant smell.
- It is a complex mixture of solid, liquid and gaseous hydrocarbons.
- Other hydrocarbons are isolated from petroleum by a process known as fractional distillation.

iii. Natural Gas

- They are hydrocarbons of low molecular masses and low boiling point.
- 85 % of Natural gas is methane and remaining 15% are gases like ethane, propane and butane.
- Natural gas is commonly known as Sui gas in Pakistan.
- Sui is the name of a place in Balochistan province.
- Natural gas is found inside the earth along with or without the reservoirs of petroleum.

Uses of natural gas

- Natural gas is used in homes and industries.
- It is used as fuel in automobiles as CNG (compressed natural gas)
- It is used as a raw material for the preparation of fertilizers in industry.

iv. Plants

- Plants are the rich sources of organic compounds
- Plants contain compounds like proteins, carbohydrates, fats, oils, vitamins etc.
- These compounds are obtained from various parts of plants like roots and shoots etc.
- The compounds obtained from plants are called natural products.
- Most of the natural products extracted from plants are used as medicines

v. Animals

- Animals are also a rich source of organic compounds.

- Organic compounds like proteins, carbohydrates, fats etc., are obtained from animals.
- These compounds are obtained in the form of milk. meat, butter, eggs etc.
- Petroleum like gasoline, diesel oil and kerosene oil are also obtained from animalsources(as fossil fuel).

Q.7 Describe vital force theory? How it was rejected?

Ans. Vital Force Theory

A Swedish chemist Berzellius in 1815 put forward a theory called Vital Force Theory. According to this theory

- Organic compounds are produced under the action of a super-mysterious force.
- This super- mysterious force exists in the living organisms only.
- Thus, Organic compounds can be derived from living organismsonly.
- Organic compounds cannot be synthesized in the laboratory.

Explanation

Before 1828, it was believed that plants and animals are the major sources of organic compounds and organic compounds cannot be synthesized in the laboratory. Moreover, according to this theory, a super-mysterious force is necessary for the preparation of organic compounds. This super-mysterious force was termed as Vital force. This vital force was supposed to be present in the living organisms only, that is why they can prepare organic compounds and one cannot prepare organic compounds in the laboratory.

Rejection of the vital force theory/synthesis of Urea



In 1828, a German chemist Friedrich Wohler synthesized urea, an organic compound for the first time in laboratory from inorganic compound like ammonium cyanate and hence the vital force theory was rejected.

Wohler's synthesis of urea

Wohler's synthesis of urea comprised of two steps i.e.

- First step is the preparation of ammonium cyanate. One of the methods for the preparation ofammonium cyanate is heating and then cooling the solution of ammonium chloride and potassium cyanate as given below.

$$KCNO + NH_4Cl \xrightarrow{heat} NH_4CNO + KCl$$

- The second step is the conversion of ammonium cyanate to urea on heating. The chemicalreaction is given below.

$$\underset{\text{Ammonium Cyanate}}{NH_4CNO_{(aq)}} \xrightarrow{heat} \underset{\text{Urea}}{NH_2-\overset{\overset{\displaystyle O}{\|}}{C}-NH_2}$$

Q.8 Describe the uses of organic compounds.

Ans. Uses of organic compounds

The uses of organic compounds are given below.

Food:

All the food we eat is almost organic in nature. Organic compounds like carbohydrates,proteins, vitamins and fats are present in milk, meat, fruits and vegetables

` respectively, are organic compounds.

Cloth:

The clothes we wear are organic in nature. Clothes are made of fibers which may be natural or synthetic. Natural fibers are obtained from silk (from larva of some insects), wool (from sheep) and cotton (from cotton plant) while synthetic fibers are nylon polyester etc.

Medicine:

Almost all the medicines are organic compounds. They are natural products and are obtained from various parts of plants like roots, shoots etc. Lifesaving drugs like anti-biotics, anti-malarial drugs, anti-inflammatory drugs are synthesized in the laboratory.

Fuel:

Fuels like gasoline, diesel, CNG and kerosene oil are organic compounds. CNG is the compressed form of the natural gas we use in our houses.

Bio-molecules:

Bio-molecules like carbohydrates, proteins, fats, lipids nucleic acid are organic in nature. These molecules are the building blocks of living organism. These molecules are necessary to sustain life.

Other products:

Other products like rubber, plastics, inks, fibers, fertilizers, insecticides, pesticides, cosmetics, paints etc., are organic compounds which we use in our daily life.

Q.9 Write a short note on alkanes. How alkanes are named?

Ans. **Alkanes**

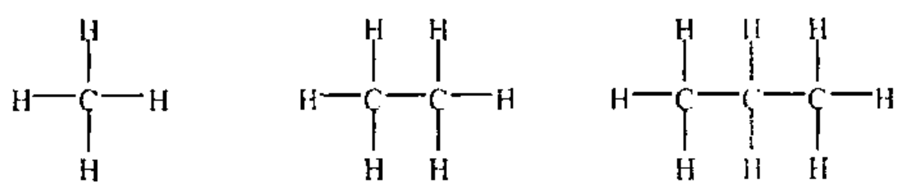
- Hydrocarbons that contain only single bond between

carbon atoms are called alkanes.

- The general formula of alkane is C_nH_{2n+2}, where "n" represents the number of carbon atoms.
- Alkanes are saturated hydrocarbons, which mean that no more hydrogen can be added to them.
- Addition reactions are unfavorable in alkanes.
- Elimination reactions are favorable by providing certain conditions.
- They are also known as paraffins because they are less reactive.The word "para" means little, "affin" means affinity i.e. they have little affinity towards reactions.
- The group of alkanes is a homologous series because each member of alkane is greater by a CH_2group from the preceding member, e.g. propane is greater by CH_2 than ethane and ethane is greater by a CH_2 group than methane.

Examples

First three members are methane, ethane and propane.



Methane (CH_4) Ethane (C_2H_6) Propane (C_3H_8)

Naming of Alkanes

Simple and straight chain alkanes are name according to the given rules.

i. The number of carbons atoms is counted.

ii. First four members are named as methane, ethane, propane and butane.

iii. Higher alkanes are named according to the Greek Numerals.

iv. The prefix pent-, hex- and hept- are used for 5,6 and 7 carbons, respectively.

v. The suffix –ane is added to the Greek numerals.

Q.10 Define Homologous series. Write down its characteristics. Give examples.

Ans. Homologous series

Homologous series is a series of organic compounds that have similar structural features but different from adjacent members by a $-CH_2-$ group.

OR

A series of organic compounds, in which every successive member is greater by a $-CH_2-$ group from the previous member, is called homologous series.

Each member of the homologous series is called homologue.

Homologues have the same chemical properties and same functional group.

Example

Alkane is a homologous series because each member of alkane is greater by a $-CH_2-$ group from the preceding member. e.g. propane is greater by $-CH_2-$ than ethane and ethane is greater by a $-CH_2-$ group than methane.

$$\underset{\text{Methane}}{CH_4} + (-CH_2-) = \underset{\text{Ethane}}{C_2H_6} + (-CH_2-) = \underset{\text{Propane}}{C_3H_8} + (-CH_2-) = \underset{\text{Butane}}{C_4H_{10}}$$

Characteristics of Homologous Series

Homologous series have the following characteristics.

- They have the same general formula.

- They have same functional group.
- They have same chemical properties.
- They have similar methods of preparation.
- Difference of a $-CH_2-$ group in adjacent members

Q.11 What are cyclo-alkanes? How are they different from acyclic alkanes?

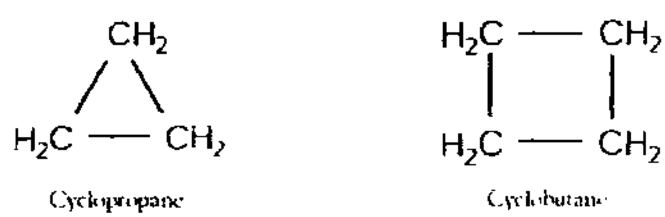
Ans. Cycloalkanes

- Alkanes, in which the carbon atoms are arranged in the form of ring or closed chain, are cycloalkanes.
- They are generally unstable than open chain alkanes.
- The prefix Cyclo- is used for naming cycloalkanes, e.g. cyclopropane, cyclobutane etc.
- Cyclopropane is the first member of cycloalkanes and as the name indicatesit contains 3 carbon atoms.
- Cyclic alkanes are less by two hydrogens from acyclic alkanes.

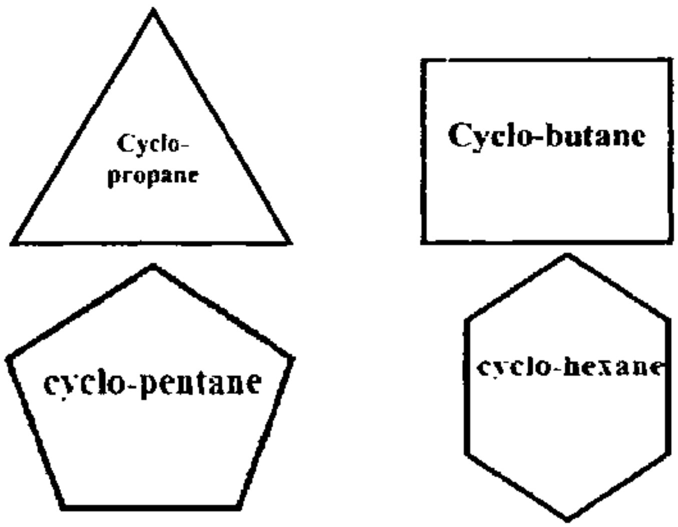
Example

The formula of

- acyclic propane is C_3H_8 and that of cyclopropane is C_3H_6
- acyclic butane is C_4H_{10} while that of cyclobutane is C_4H_8.



Or simple geometrical shapes are also used in which each corner represents a carbon atom e.g.



Q.12 What are Alkyl Radicals. Give examples.

Ans. Alkyl Radicals

- Alkyl radicals are a group of atoms that are formed after removing one hydrogen atom from an alkane molecule.
- It is generally represented by English alphabet "R".
- The general formula of alky radical is C_nH_{2n+1}
- Alkyl radicals are named by replacing the "ane" of the alkane by "yle".

Examples:

Alkanes	Removing one Hydrogen	Alky radical formed	Name of alky radical
CH_4	-H	CH_3-	Methyl
C_2H_6	-H	C_2H_5-	Ethyl
C_3H_8	-H	C_3H_7-	Propyl
C_4H_{10}	-H	C_4H_9-	Butyl
C_5H_{12}	-H	C_5H_{11}-	Pentyl

Q.13 Define Functional group and explain the types of functional groups.

Ans. Functional Group

Definition:

- An atom or group of atoms that are responsible for the specific properties ofan organic compound is called functional group.
- Functional group is usually attached to an alkyl group (R) but it may attach to other groups also like aryl (C_6H_5-).
- The alkyl group usually determines the physical properties of an organic compound.
- The functional group attached to an alkyl group specifically determines the chemical properties of an organic compound, but it can also give information about the physical properties as well.

Functional groups containing carbon, hydrogen and oxygen

These functional groups containing carbon, hydrogen and oxygen are;

i. Alcoholic Functional Group

Functional group of Alcohol is –OH. General formula of Alcohol is R-OH. Where R represents alkyl Group and OH represents alcoholic group.

Examples

Alkyl Groups	Functional Group	Derivative	Name
CH_3–	–OH	CH_3-OH	Methanol
C_2H_5–	–OH	C_2H_5-OH	Ethanol

ii. Ether Functional Group

Function group of ether is –O–. General formula of ether is R-O-R. Where R represents alkyl group and –O– represents ether functional group.

Examples

Alkyl Groups	Functional Group	Derivative	Name
CH_3–	–O–	CH_3–O–CH_3	Methanol
C_2H_5–	–O–	C_2H_5–O–C_2H_5	Ethanol

iii. Carbonyl Group

Carbon double covalently bonded with oxygen atom is called a carbonyl carbon.

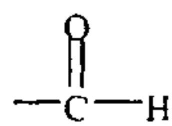
Functional group containing a carbonyl carbon is called carbonyl functional group and compounds containing a carbonyl group are called carbonyl compounds.

General formula of carbonyl compounds is R-CO-R.

Carbonyl group is further divided into two groups Aldehydes and Ketones.

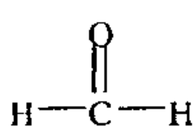
a. Aldehyde:

Functional groups containing a –CHO group is called aldehyde functional group. In aldehydes, carbonyl carbon is attached to hydrogen atom one side and a carbon atom on the other side.

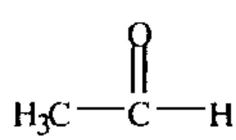


Aldehyde group (–CHO)

Examples



Formaldehyde

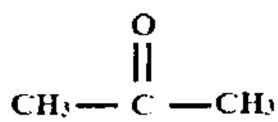


Acetaldehyde

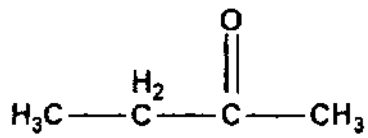
b. Ketone:

Carbonyl carbon is the functional group of ketones. Compounds containing carbonyl group bonded to a carbon atom (in the form of alkyl groups)on both sides are called ketones.

Examples



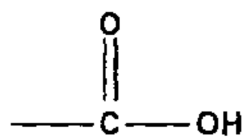
Di-methyl ketone (acetone)



Ethyl methyl ketone

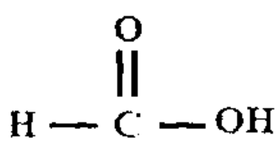
iv. Carboxylic Acids

Functional group of carboxylic acid is –COOH. General formula of carboxylic acid is R-COOH where R represents Alkyl group.

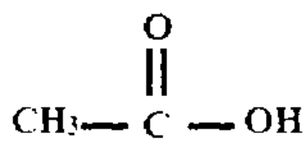


Carboxylic acid group (–COOH)

Examples



Formic Acid



Ethanoic acid(acetic acid)

Functional groups containing carbon, hydrogen and nitrogen

Those organic compounds containing carbon, hydrogen and nitrogen are called amines. The functional group of these compound is $-NH_2$. The general formula is $R-NH_2$. Where R stands for alkyl group.

Example

Methylamine (CH_3-NH_2)

Ethylamine (C_2H_5-NH_2)

Functional group containing carbon, hydrogen and halogens

Compounds containing carbon, hydrogen and halogens are called alkyl halides. Functional group of halides is represented by "X" where "X" may be F, Cl, Br, and I. General formula of alkyl halide is R–X

Examples:

CH_3–Cl	CH_3–Br
Methylchloride	Methylbromide

Double and Triple bonds

a. **Double bonds hydrocarbons**

Hydrocarbons containing double between carbon atoms are called alkenes.

Examples:

$CH_2 = CH_2$	CH_3–CH=CH_2	CH_3 –CH_2 –CH =CH_2
Ethene	Propene	1-Butene

b. **Triple Bonds Hydrocarbons**

Hydrocarbons which consist of triple bonds between two carbon atoms are called alkynes.

Examples:

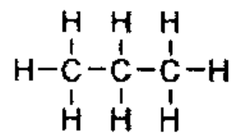
$CH \equiv CH$	$CH_3 — C \equiv CH$
Ethyne	Propyne

EXERCISE

A. Choose the correct option.

1. The condensed structural formula of butane is,

a. $CH_3-CH_2-CH_2-CH_3$ b. $CH_3(CH_2)_2CH_3$

c. C_4H_{10} d. 

2. The compounds C_6H_{12} must have

a. All single bonds

b. At least one double bond

c. At least one triple bond

d. All double bonds

3. Which of the following is inorganic compound

a. CH_4 b. CH_3OH

c. NaCN d. CH_3Cl

4. Alkyl halides composed of carbon, hydrogen and

a. Oxygen b. Nitrogen

c. Halogen d. Sulphur

5. Which of the following is an alcohol

a. CH_3-O-CH_3 b. CH_3-CH_2-OH

c. CH_3COOH d. CH_3-COH

6. Unsaturated hydrocarbon is

a. C_3H_8 b. C_2H_6

c. C_3H_6 d. CH_4

7. The functional group of ketone is

a. $-\overset{\overset{O}{\|}}{C}-H$ b. $-\overset{\overset{O}{\|}}{C}-$

c. $-\overset{\overset{O}{\|}}{C}-OH$ d. $-C-O-C-$

8. Natural gas is mainly composed of

a. CH_4 b. C_2H_8

c. C_2H_6 d. C_2H_2

9. Catenation is the linkage of carbon with other

a. Oxygen atoms b. Carbon atoms

c. Nitrogen atoms d. Halogens

10. Oxygen is attached on both sides to carbon atom in

a. Alcohol b. Ketone

c. Aldehyde d. Ether

ANSWERS:

1	b	2	b	3	c	4	c	5	b
6	c	7	b	8	a	9	b	10	d

B. Write short answers to the following questions.

i. Define the functional group. Give some example of functional groups containing oxygen.

Ans. See Question 13

ii. How can we obtain the organic compounds from natural sources?

Ans. See Question 6

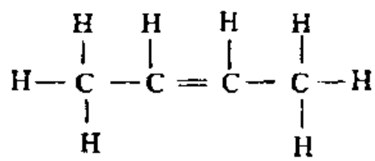
iii. What are cycloalkanes?

Ans. See Question 11

iii. Write downs the examples of three unsaturated hydrocarbons with structural and condensed formula.

Ans. Examples of unsaturated hydrocarbons are

Butene

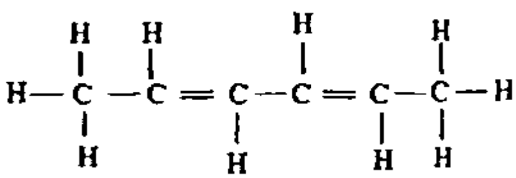


Structural formula

$CH_3(CH)_2CH_3$

Condensed Formula

Hexene

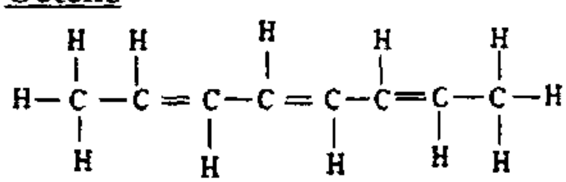


Structural Formula

$CH_3(CH)_4CH_3$

Condensed Formula

Octene



Structural Formula

$CH_3(CH)_6CH_3$.

Condensed Formula

iv. Define Hydrocarbons and briefly discuss the importance?

Ans. **Hydrocarbons**

Those compounds, which contain carbon and hydrogen, are called hydrocarbons.

Importance

- Hydrocarbons are among the most important natural

resources.

- They play a crucial role in our everyday life.
- They are the main source of electrical and heat energy.
- Various gases like liquefied petroleum gas(LPG), natural gas (sui gas) used as domestic fuel are hydrocarbon.
- Hydrocarbons like Diesel, petrol and compressed natural gas (CNG), are used for running automobiles.
- Theyare important, as they are used for manufacturing polymers like polythene (plastics), polystyrene etc.
- The thinner we used as a solvent for paints is hydrocarbon in nature.

v. How alkyl radicals are formed? Discuss it with examples.

Ans. See Question 12

vi. List some uses of organic compounds.

Ans. See Question 8

vii. Give the general formula of the following homologue series.

a. Alkane b.Alkenes c. Alkynes

Ans. a.Alkanes C_nH_{2n+2}

b. Alkenes C_nH_{2n}

c. Alkynes C_nH_{2n-2}

viii. Why organic compounds are volatile in nature?

Ans. Organic compounds are volatile in nature because

- They have weak intermolecular forces.
- They have high vapor pressure.
- They have low boiling point.

ix. Why the chemical properties of a homologous series always same?

Ans. Homologous series

A series of organic compounds, in which every successive member is greater by a $-CH_2-$ group from the previous member, is called homologous series.

Members of homologous series are said to be homologues of one another.

The chemical properties of an organic compound is due to the type of functional group that they posses. As homologues contain the same type of functional group, therefore they have the same chemical properties.

C. Write detailed answers to the following questions.

1. a. List the different characteristic of organic compounds.

Ans. See Question 5

b. Which of these is not an unsaturated molecule?

(i) C_4H_6 (ii) C_6H_6 (iii) C_8H_{18} (iv) C_3H_6

Ans. C_8H_{18}

c. Define Destructive distillation of Coal. Name the products obtained by the destructive distillation of coal.

Ans. Destructive distillation of coal (Carbonization of Coal)

Heating coal in the absence of air is called destructive distillation of coal or carbonization.

The products obtained by the destructive distillation of coal are;

- Coal gas
- Coke
- Coal tar

- Ammonical liquor

2. a. What is catenation?

b. How does catenation contribute to the diversity of organic compounds.

Ans. See Question 4 Topic: Catenation

3. a. What information about a compound is provided by a structural formula?

Ans. See Question 2 topic structural formula

b. How are structural formula used in organic chemistry?

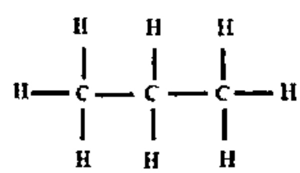
Ans. See Question 2 topic structural formula

4. a. What do the terms saturated and unsaturated mean when applied to hydrocarbons?

Ans. Saturated hydrocarbons

Those hydrocarbons in which each carbon atom in a molecule forms four single covalent bonds with other atoms are called saturated hydrocarbons. In the molecules of a saturated hydrocarbon, all the bonds are single, and no double or triple covalent bond is present.Addition reactions are unfavorable in saturated hydrocarbons.

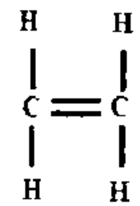
Example: Propane



Unsaturated hydrocarbons.

Those organic compounds, in which at least one double bond or triple bond is present. Addition reactions are favorable in unsaturated hydrocarbons.

Example: Ethene



b. What other means these terms have in chemistry?

Ans. The other meaning of saturated and unsaturated may refer to saturated solution and unsaturated solution.

Saturated solution:

A solution, which cannot dissolve more solute at a particular temperature, is called saturated solution. As no more hydrogen can be added to alkanes therefore they are known as saturated hydrocarbons.

Unsaturated solution:

A solution, which can dissolve more solute at a particular temperature, is called unsaturated solution. As more hydrogen can be added to alkenes and alkynes, therefore they are known as unsaturated hydrocarbons.

c. Classify alkenes, alkanes, alkynes and aromatic hydrocarbons as either saturated or unsaturated.

Ans. **Alkanes** are saturated hydrocarbons because they have carbon-carbon single covalent bond and no double or triple covalent bond is present.

Alkenes, and **aromatic hydrocarbons** are unsaturated hydrocarbons because alkenes and aromatic hydrocarbons contain a carbon-carbon double covalent bond.

Alkynes are also unsaturated hydrocarbons because they contain carbon-carbon triple covalent bond.

Q.5 a. Can you explain the term homologous series?

Ans. See Question 10

b. How the straight chain hydrocarbons are named?

Ans. Naming of Alkanes

Simple and straight chain alkanes are name according to the given rules.

i. The number of carbons atoms is counted.

ii. First four members are named as methane, ethane, propane and butane.

iii. Higher alkanes are named according to the Greek Numerals.

iv. The prefix pent- , hex- and hept- are used for 5,6 and 7 carbons respectively.

v. The suffix –ane is added to the Greek numerals.

c. Name the straight chain alkane with the molecular formula C_8H_{18}.

Ans. The name of the straight chain alkane with molecular formula C_8H_{18} is Octane.

--❀❀❀--

Unit 12

Hydrocarbons

Q.1 Write a brief note on hydrocarbons.

Ans. Hydrocarbons

The simplest type of organic compounds which are composed of only carbon and hydrogen, are called hydrocarbons.

- Hydrocarbons are non-polar and are not soluble in water.
- They are soluble in non-polar solvents only.
- They are covalent compounds, as they possess covalent bond.
- Hydrocarbons are among the most important natural resources. They are the main source of electrical and heat energy. Various gases like liquefied petroleum gas(LPG), natural gas (sui gas) used as domestic fuels are hydrocarbons.
- They are used for manufacturing polymers like polythene (plastics), polystyrene etc.
- Hydrocarbons like Diesel, petrol and compressed natural gas (CNG), are used for running automobiles.
- Hydrocarbons are further classified into saturated hydrocarbons i.e. alkanes and unsaturated hydrocarbons i.e. alkenes and alkynes.

Q.2 Write a brief note on alkanes.

Ans. Alkanes

Hydrocarbons that contain only single covalent bond between carbon atoms are called alkanes. They are also

known as saturated hydrocarbons because in alkanes all the four bonds of carbon are single covalent bonds.

Reactivity:

They are less reactive that is why they are also known as paraffins.The word "para" means little, while "affain" means affinity i.e. they have little affinity towards reactions.

Mode of reactions:

Although, they are less reactive, but they undergo substitution reactions under certain conditions. Addition reactions are unfavorable in alkanes.

Alkane as a homologous series:

Alkane is a homologous series because each member of alkane is greater by a methylene(CH_2) group from the preceding member e.g. propane is greater by $-CH_2-$ than ethane and ethane is greater by a $-CH_2-$ group than methane.

Classification:

Alkanes are classified into closed chain alkanes(cyclic alkanes) and open chain alkanes(acyclic alkanes). Cyclic alkanes have two hydrogens less than acyclic alkanes.

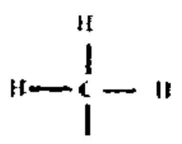
General formula:

The general formula of open chain alkanes is C_nH_{2n+2}, where "n" represents the number of carbon atoms.

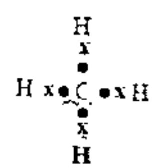
Examples

First five members of alkanes are given below.

- Methane(CH_4)

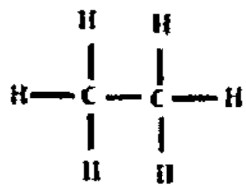


Structural Formula

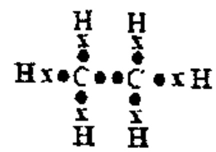


Electron Dot and Cross formula

- **Ethane** (C_2H_6)

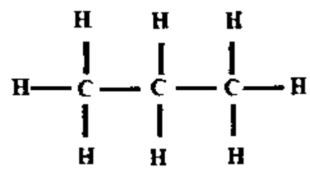


Structural Formula

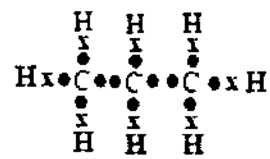


Electron Dot and Cross formula

- **Propane** (C_3H_8)

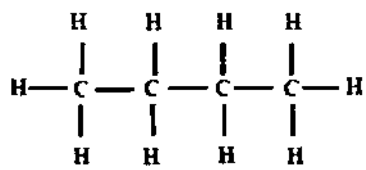


Structural Formula

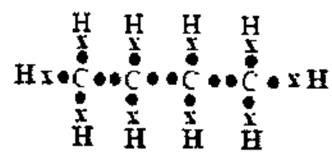


Electron Dot and Cross formula

- **Butane** (C_4H_{10})

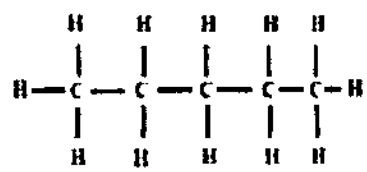


Structural Formula

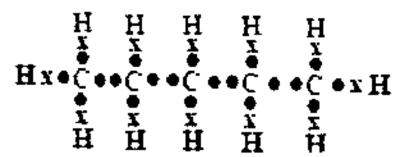


Electron Dot and Cross formula

- **Pentane** C_5H_{12}



Structural Formula



Electron Dot and Cross formula

Q.3 List the IUPAC rules for naming alkanes.

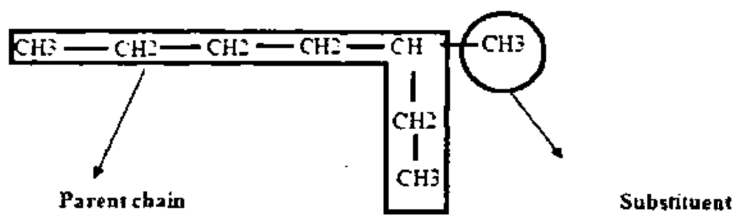
Ans. In International Union of Pure and Applied Chemistry (IUPAC) rules, each of the different compounds has a different name. These rules are given below.

1. Selection of the longest continuous chain containing

maximum number of substituent's.

(The longest continuous chain is called parent chain, Substituent are atoms or group of atoms that are attached to carbon atom)

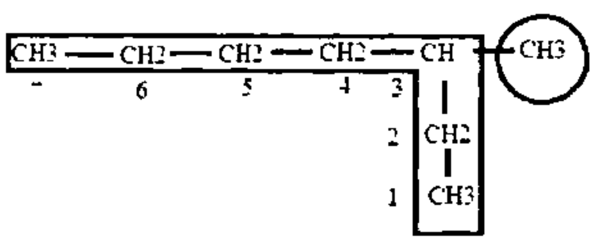
<u>Example</u>



Name of parent chain = Heptane name of substituent = methyl

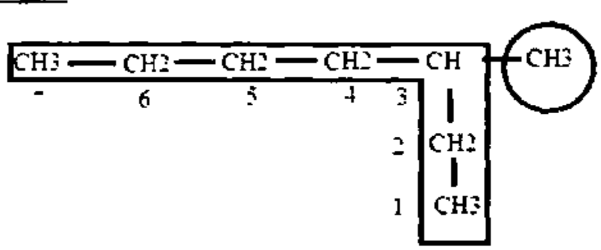
2. Numbering the carbon atoms of the parent chain in such a way that the substituent comes on lowest number.

<u>Example</u>



3. Parent name will be given to alkane according to the common system i.e. pentane for five carbons and hexane for six carbons.

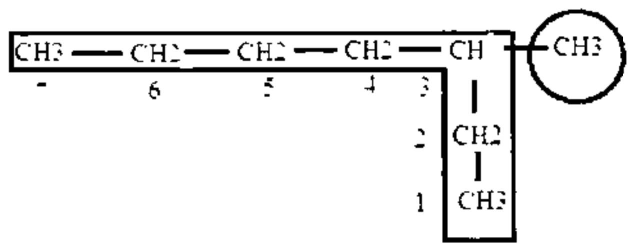
<u>Example</u>



Parent name in this case will be heptane as there are seven carbons.

4. Number of the substituent(s), following the name of the substituent(s) is written first and parent name is written after the name of the substituent.

<u>Example</u>



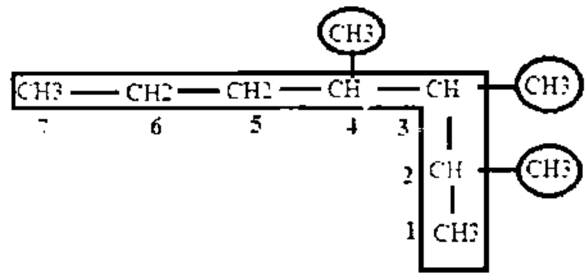
3-methyl heptane (in this case)

5. Number and name of the substituent is separated by a dash (–).

6. If two or more than two same substituents are attached to a parent chain, each substituent will be numbered accordingly and the prefix di-, tri- etc. will be written before the name of the substituent.

<u>Example</u>

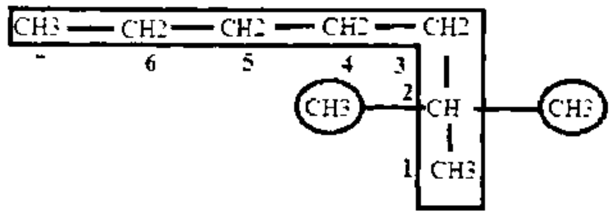
As we have three substituents in this example so the IUPAC name in this case will be



2,3,4-trimethyl heptane

7. If same substituent are attached to same carbon atom then the number of that carbon atom will be repeated twice.

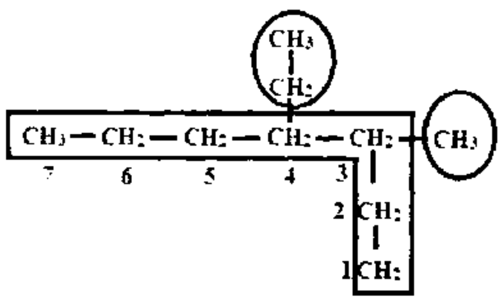
Example



2,2-dimethyl heptane

8. If different substituents are attached to a parent chain, then the substituents will be named in alphabetical order. i.e. methyl will be named after ethyl.

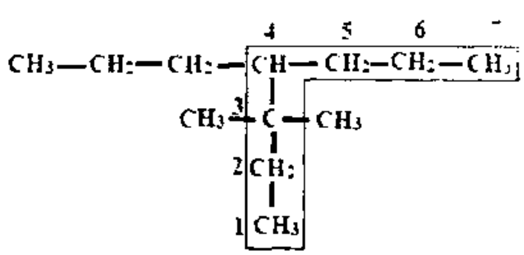
Example



4-ethyl-3-methyl heptane

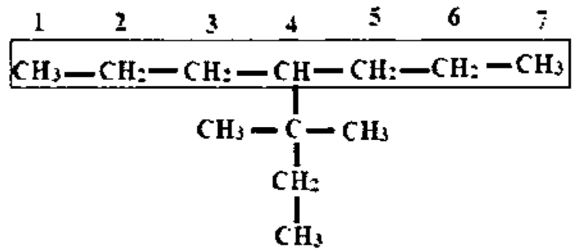
9. If more than one longest continuous chainis present, the one with greater number of substituents will be taken as the parent chain.

Examples



(Right Selection)

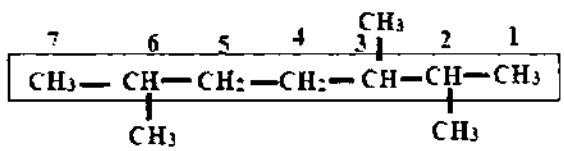
(3,3-dimethyl-4-propyl heptane)



(Wrong Selection)

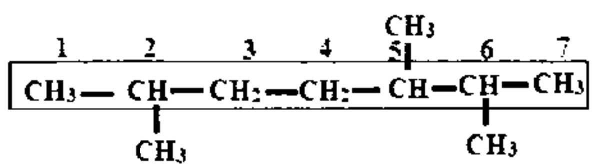
10. If a substituent comes on lowest number from either end of the carbon atom, then numbering will be done in such a way that the next substituent comes on lowest number.

<u>Examples</u>



(Right Numbering)

2,3,6-trimethyl heptanes



(Wrong Numbering)

11. A comma will be used for separating two digits, and a dash will be used for separating digits and alphabets. Examples are given above.

Q.4 How alkanes are prepared?

Ans. Alkanes are saturated hydrocarbons. It is further divided into cyclic alkanes and acyclic alkanes. The methods of preparation for both type of alkanes is similar. There are various methods for the preparation

of alkanes. The two common reactions used for the preparation of alkanes are

- Addition reaction
- Reduction of alkyl halides

Addition Reaction

Addition reaction is favorable in unsaturated hydrocarbons like alkenes and alkynes. It is a type of reaction in which an atom or group of atoms are added to unsaturated compounds. There are various types of addition reactions. One of them is hydrogenation.

Hydrogenation of alkenes and alkynes

Addition of hydrogen to alkenes and alkynes is termed as hydrogenation reaction. During this reaction, the unsaturated hydrocarbons like alkenes and alkynes are converted to saturated hydrocarbons like alkanes. Conditions necessary for this reaction are Ni/Pt catalyst and 250°C-300°C temperature.

a. Hydrogenation of alkenes

Addition of hydrogen across the double bond of alkenes in the presence of nickle or platinum as a catalyst and 250°C-300°C temperature is called hydrogenation of alkenes.

Chemical Reaction

The reaction is given below.

$$H_2C{=}CH_2 + H_2 \xrightarrow[250^\circ C - 300^\circ C]{Ni/Pt} \underset{\text{Ethane}}{H_3C{-}CH_3}$$

b. Hydrogenation of alkynes

Alkynes can be hydrogenated to alkanes in two steps. In the first step alkynes are hydrogenated to alkenes in the presence ofnickle or platinum as a catalyst and 250°C-300°C

temperature. The second step is the hydrogenation of alkenes to alkanes under the same conditions.

Chemical Reaction

The reactions are given as under.

i. $HC{=}CH + H_2 \xrightarrow[250^\circ C-300^\circ C]{Ni/Pt} H_2C{=}CH_2$ (Ethene)

ii. $H_2C{=}CH_2 + H_2 \xrightarrow[250^\circ C-300^\circ C]{Ni/Pt} H_3C{-}CH_3$ (Ethane)

Reduction of alkyl halides

Reduction of alkyl halides is the addition of atomic hydrogen also known as nascent hydrogen (hydrogen at the time of its formation/birth) to alkyl halides. As a result, a hydrogen atom substitutes the halogen (X) group of alkylhalide. This reaction occurs in the presence of Zinc (Zn) dust and hydrochloric acid (HCl). The alkyl group of alkyl halide is converted to their corresponding alkane. For example, methyl will be converted to methane and ethyl is converted to ethane.

Chemical Reaction

The general reaction for the reduction of alkyl halide is given below.

$$R{-}X + 2[H] \xrightarrow{Zn/HCl} R{-}H + HX$$

If methyl iodide is reduced to methane, then the reaction will be:

$$CH_3{-}I + 2[H] \xrightarrow{Zn/HCl} CH_3{-}H + H{-}I$$

If the alkyl halide is ethyl bromide, then the reaction can be written as:

$$CH_3{-}CH_2{-}Br + 2[H] \xrightarrow{Zn/HCl} CH_3{-}CH_2{-}H + HBr$$

Q.5 Write down the physical properties of alkanes.

Ans. Physical Properties of alkanes

The physical properties of alkanes are given below.

Physical state

First four members of alkanes are colorless gasses, next thirteen members are colorless liquids while higher alkanes are solids.

Solubility

They are insoluble in water because they are non-polar and soluble in non-polar solvents like benzene, ether, acetone etc.

Melting Point and Boiling Point

Alkanes have low melting and boiling points. Their melting and boiling points increase with the increase in molecular weight. Thus, higher alkanes have high melting point and boiling point than lower alkanes.

Density

Density of alkanes also increases with the increase in molecular weight. Thus, higher alkanes have greater density than lower alkanes.

Viscosity

Viscosity of alkanes also increases with the increase in molecular weight. Thus, higher alkanes will be more viscous than lower alkanes.

Inflammability

Alkanes are inflammable. Their inflammability decreases with the increase in molecular size of alkane. This is due to the increase in percentage of carbon in higher alkanes.

Q.6 Write down the chemical properties of alkanes. OR Write the important reactions of alkanes.

Ans. Alkanes are less reactive and therefore they are also known as paraffins. This is due to the presence of strong covalent bonds between C-C and C-H. Although, they are less reactive, but they undergo substitution reactions by providing certain conditions while addition reactions are unfavorable in alkanes.Substitution reaction is that type of reaction in which an atom or a group of atoms are replaced by another atom or group of atoms.

Alkanes generally undergo the following reactions

- Halogenations
- Combustion

Halogenation

The substitution of hydrogen of alkane by a halogen is called halogenation. Halogenation of alkanes occurs in the presence of ultra violet (UV) sunlight. Alkane undergoes substitution reactions easily as they are saturated hydrocarbons.

Chemical Reactions

$$\underset{\text{Methane}}{H_3C-H} + Cl-Cl \xrightarrow{\text{UV light}} \underset{\substack{\text{Cholromethane} \\ \text{or methyl chloride}}}{H_3C-Cl} + HCl$$

This reaction does not stop at this point, it enters into a series of reactions and in every reaction a chlorine atom replaces a hydrogen atom until all the hydrogens are replaced by chlorine atoms.

As a result, di, tri and tetra chloromethane are formed.

The chemical reactions are given below.

$$\underset{\text{Methyl chloride}}{CH_3{-}Cl} + Cl{-}Cl \xrightarrow{\text{UV light}} \underset{\text{Di-chloromethane or methylene chloride}}{CH_2Cl_2} + HCl$$

$$\underset{\text{Methylene chloride}}{CH_2Cl_2} + Cl{-}Cl \xrightarrow{\text{UV light}} \underset{\text{Tri-chloromethane or Chloroform}}{CHCl_3} + HCl$$

$$\underset{\text{Trichloromethane}}{CHCl_3} + Cl{-}Cl \xrightarrow{\text{UV light}} \underset{\text{tetra-chloromethane or Carbon tetra-chloride}}{CCl_4} + HCl$$

Combustion

The second common reaction of alkane is combustion reaction. It is commonly known as burning. Depending upon the supply of Oxygen, combustion may be complete combustion or incomplete combustion.

Complete Combustion

In completecombustion, alkanes are burned completely in the presence of oxygen and thus produce carbon dioxide (CO_2) and water (H_2O) molecules.It is an exothermic reaction, as it yields a great deal of heat. That is why alkanes are used as fuel.

Chemical Reaction

The reaction is as under.

$$CH_4 + 2O_2 \xrightarrow{\text{complete combustion}} CO_2 + 2H_2O + \text{Heat}$$

Incomplete Combustion

Incomplete combustion of alkanes occurs in limited supply of oxygen, which produces carbon monoxide, water and un-burnt carbon.

Chemical Reaction

The reaction is given below.

$$3CH_4 + 4O_2 \xrightarrow{\text{incomplete combustion}} 2CO + 6H_2O + C + \text{Heat}$$

Carbon mono-oxide produced in this reaction is a poisonous gas that creates suffocation and causes death. Modern vehicles have catalytic converter fitted in their silencers, which convert the carbon mono-oxide produced in the internal combustion engine to carbon dioxide which is a less harmful gas.

Q.7 Write a note on alkenes.

Ans. Alkenes

Definition:

Those unsaturated hydrocarbons which containat least one double covalent bond between carbon atoms are called alkenes. They are also known as Olefins. Olefins is a Latin word which means oil producing.

Reactivity:

As alkenes contain a double covalent bond, therefore they are more reactive than alkanes i.e.the π-electrons of the double covalent bond are loosely held and are responsible for the reactivity of alkenes.

Functional group of alkenes:

The double bond present in alkenes is the functional group of alkenes as it gives some characteristic features to alkenes and is responsible for the chemical properties of alkenes.

Mode of reactions:

As alkenes are unsaturated hydrocarbons therefore they undergo addition reactions.

Alkene as a homologous series:

Alkene is a homologous series because each member of alkene is greater by a methylene (CH_2) group from the preceding member e.g. butene is greater by CH_2 than propene and propene is greater by a CH_2 group than ethene.

General formula:

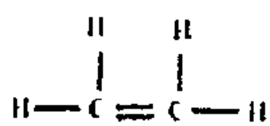
The general formula of alkenes is C_nH_{2n} where "n" represents the number of carbon atoms.

The first member of alkenes is ethene i.e. C_2H_4

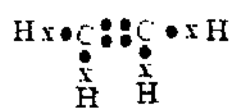
Examples

First fourmembers of alkenes and their structural,dot and cross formulas are given below.

- EtheneC_2H_4

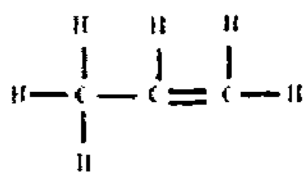


Structural formula

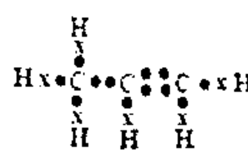


Electron dot and cross formula

- PropeneC_3H_6

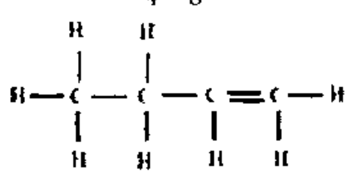


Structural formula

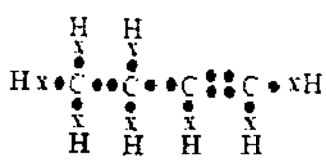


Electron dot and cross formula

- ButeneC_4H_8

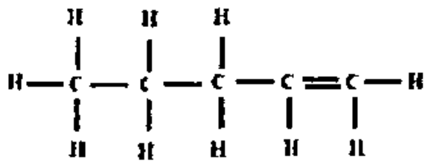


Structural formula

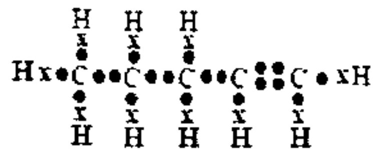


Electron dot and cross formula

- PenteneC_5H_8



Structural formula



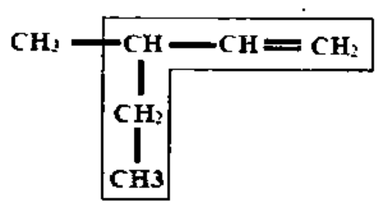
Electron dot and cross formula

Q.8 How alkenes are named according to IUPAC?

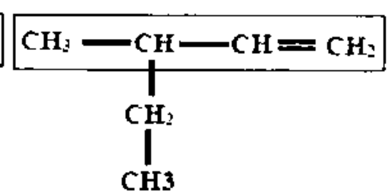
Ans. Basic rules of nomenclature of alkanes and alkenes are same. The following rules should be obeyed while naming alkenes.

i. Selection of the longest continuous chain containing a double bond.The number of carbon in the longest chain will determine the parent name.

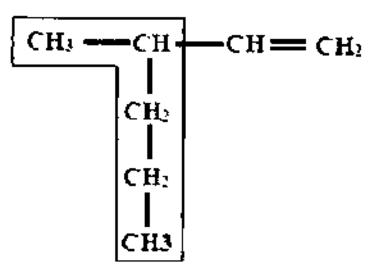
<u>Examples</u>



Right selection



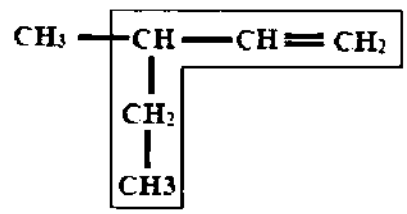
Wrong selection



Wrong selection

ii. The parent name will be similar to that of alkane, only the "ane" of alkane will be replaced by "ene"

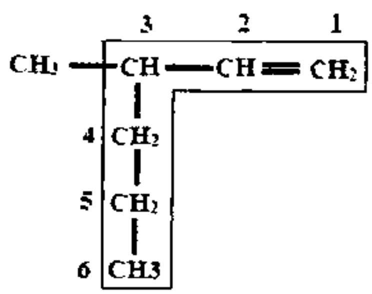
Example



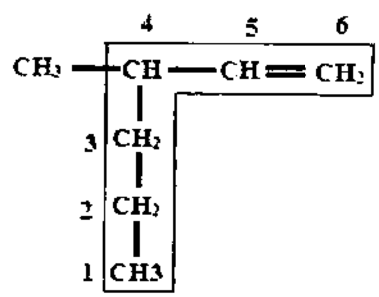
Parent name = Pentene (pentene from pentane of alkane)

iii. Numbering the carbon atoms of the parent chain would be in such a way that the double bond comeson lowest number and both carbons of double bond must be included in numbering as given below.

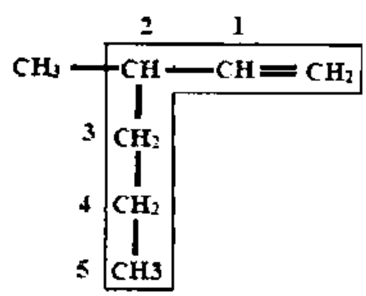
Examples



Right Numbering



Wrong numbering

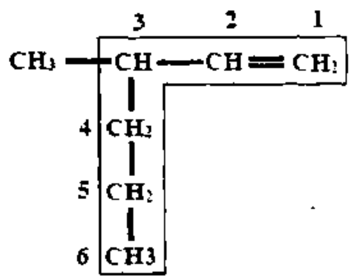


Wrong numbering

iv. The number of first atom of the double bond will determine the position of the double bond.

Example

The name in this case will be:



Correct name = 3-methyl-1-hexene

Incorrect name = 3-methyl-2-hexene

v. Number of carbons to which the substituent is attached, will indicate the position of the substituent as given in step 4.

Q.9 Write down the preparation of alkenes.

Ans. Preparation of alkenes

Alkenes are unsaturated hydrocarbons and they are generally prepared through elimination reaction.

Elimination reaction is that type of reaction in which atoms that are attached to adjacent atoms of a molecule are removed to form a double or triple bond. Elimination reaction is opposite to addition reaction.

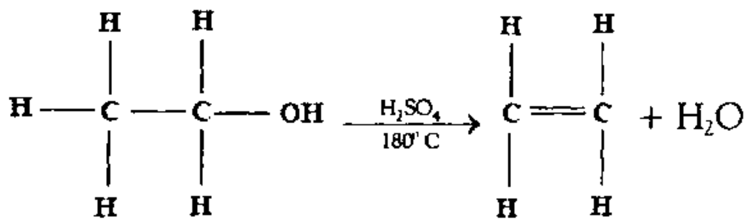
Following are the two common elimination reactions used for the preparation of alkenes.

Dehydration of Alcohols

Removal of water molecule from alcohol is called dehydration of alcohol. This reaction occurs in the presence of concentrated sulphuric acid (H_2SO_4) at 180°C. Sulphuric acid acts as a dehydrating agent in this reaction.

Chemical Reaction

The dehydration of alcohol for the preparation of ethene is given below.



Ethyl alcohol(ethanol) Ethene Water

Dehydrohalogenation of alkyl halides

The removal of hydrogen and halogen from an alkyl halide for converting it to alkene is called dehydro-halogenation of alky halides.

As alkyl halides contain an alkyl group and a halogen group, therefore, they can be converted to alkene in the presenceof hot alcoholic KOH.

In this reaction an alkyl halide like ethyl chloride is heated with an alcoholic solution of potassium hydroxide (KOH) as a result a molecule of hydrogen halide is removed along with the formation of ethene.

Chemical Reaction

The reaction is given below.



Q.10 Write down the physical properties of alkenes.

Ans. **Physical Properties of Alkenes**

Physical properties of alkenes are given below.

Physical state

Alkenes exist in all three states, first three members of alkenes are colorless gases and next fourteen members are liquid while higher alkenes are solids.

Solubilty

They are insoluble in water because they are non-polar.

They are polar and soluble in non-polar solvents only.

Melting Point and Boiling Point

The melting points and boiling points of alkenes increase with increase in molecular mass.

Density

The densities of alkenes increase with increase in molecular mass.

Q.11 Write the chemical properties of alkenes.

OR Write the important chemical reactions of alkenes.

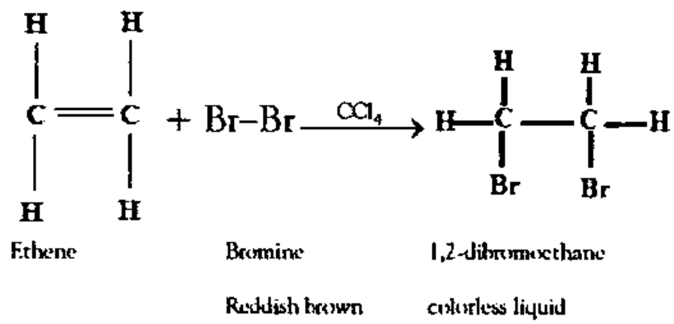
Ans. Alkenes contain a double bond and are known as unsaturated hydrocarbons. Due to the presence of double bond alkenes easily undergo addition reaction. In other words, addition reaction is the characteristic property of alkenes. The π-electrons in the double bond are responsible for the reactivity of alkenes. The following type of addition reactions are generally occurring in Alkenes.

Addition of Halogens

Addition of halogens means the addition of group VIIA elements to alkenes. These elements may be fluorine,chlorine, bromine etc. Bromine is a reddish brown color liquid, when it is added to an alkene like ethene in the presence of an inert solvent like carbon tetra chloride (CCl_4), the reddish brown color of bromine disappears due to the

formation of a colorless liquid known as 1,2-dibromoethane.

Chemical Reaction



Addition of hydrogen halides

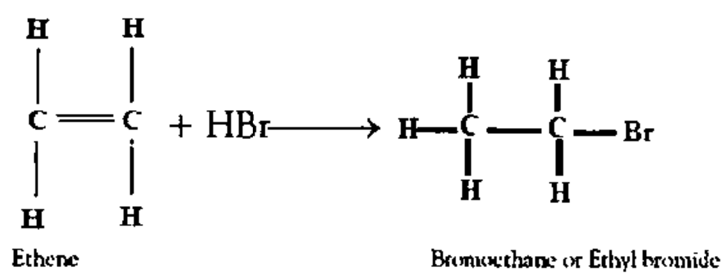
Addition of hydrogen and a halogen is called addition of hydrogen halides. Some of the common hydrogen halides are HCl, HBr and HI. The order of reactivity of alkenes towards hydrogen halides is given below.

HI >HBr>HCl

When hydrogen bromide HBr reacts with ethene, ethyl bromide is formed. If HBr reacts with propene, then propyl bromide will be formed.

Chemical Reaction

The reaction is given below.



Hydrogenation

Addition of hydrogen is called hydrogenation. Hydrogenation occurs in the presence of Ni/Pt as a catalyst

and at 250-300°C temperature(same reaction used for preparation of alkanes). In hydrogenation, the unsaturated hydrocarbons like alkenes and alkynes are converted to saturated hydrocarbons like alkanes. Hydrogenation is an exothermic process.

Chemical Reaction

The following reaction shows the hydrogenation of ethene.

$$\underset{\text{Ethene}}{H_2C=CH_2} + H_2 \xrightarrow[250^\circ C-300^\circ C]{Ni/Pt} \underset{\text{Ethane}}{H_3C-CH_3}$$

Unsaturated hydrocarbons usually occur in liquid state. As hydrogenation converts unsaturated hydrocarbons(liquid) to saturated hydrocarbons(solid) therefore it is industrially used for the conversion of vegetable oils into ghee.

Oxidation with $KMnO_4$

Alkene like ethene reacts with potassium permanganate ($KMnO_4$) in acidic medium. The purple colour of $KMnO_4$ disappears due to the formation of ethylene glycol, manganese dioxide (MnO_2) and potassium hydroxide (KOH).This reaction is commonly known as Bayer's test.

Chemical Reaction

$$\underset{\text{Ethene}}{3H_2C=CH_2} + \underset{\text{Potassium permanganate}}{2KMnO_4} + H_2O \xrightarrow{Acid}$$

$$3\underset{\text{OH}}{\underset{|}{CH_2}}-\underset{\text{OH}}{\underset{|}{CH_2}} + 2MnO_2 + 2KOH$$

Ethylene glycol ManganesedioxidePotassiumHydroxide

Q.12 What is Bayer's Test for what purpose it is used?

Ans. **Bayer's Test**

When oxidation of alkene is carried out by acidified

potassium permanganate, the purple colour of potassium permanganate $KMnO_4$disappears.

The disappearance of purple colour of potassium permanganate proves that an addition reaction has taken place. The two hydroxyl (OH) groups have been added across the double bond of ethene.

When the same reaction is carried out for a saturated hydrocarbon like ethane no change in colour occurs. The purple colour of potassium permanganate retains which proves that no addition reaction has occurred.

This test is called Bayer's Test and it is used for the detection of alkenes.

Chemical Reaction

The reaction is given below.

$$3H_2C{=}CH_2 + 2KMnO_4 + H_2O \xrightarrow{\text{Acid}}$$

Ethene Potassium permanganate

$$3\underset{\displaystyle OH}{\underset{|}{CH_2}}-\underset{\displaystyle OH}{\underset{|}{CH_2}} + 2MnO_2 + 2KOH$$

Ethylene glycol Manganesedioxide PotassiumHydroxide

Q.13 Why alkenes are more reactive than alkanes and alkynes?

Ans. Alkenes are generally more reactive than alkanes because they are unsaturated hydrocarbons. Alkenes readily undergo addition reactions because,

- Theycontain a double covalent bond, i.e.a δ-bond and π-bond. The π-bond is a weaker bond, as the electrons in this bond are loosely held by the bonded atoms.Therefore, the π-electrons of the double covalent bond in alkenes are readily available for the

reaction to take place. In short, the π-electrons of alkenes are responsible for the reactivity of alkenes.

- Alkynes being SP–hybridized having 50% character of s-orbital are more stable than alkenes being SP^2–hybridizedhaving 33% character of s-orbital. Increase in s-character leads to the stability of a compound.

Q.14 Write a note on alkynes.

Ans. Definition:

Those unsaturated hydrocarbons, which contain at least one triple covalent bond between carbon atoms, are called alkynes.

Reactivity:

They are more reactive than alkanes but less reactive than alkenes because the π-electrons in alkynes are more tightly held than alkenes by the nucleus of both the atoms. Its due to the presence of threecovalent bonds.

Functional group of alkenes:

The triple bond present in alkynes is the functional group of alkynes as it gives some characteristic features to alkynes and is responsible for the chemical properties of alkynes.

Mode of reactions:

As alkynes are unsaturated hydrocarbons therefore they undergo addition reactions.

Alkyne as a homologous series:

Alkyne is a homologous series because each member of alkyne is greater by a methylene (CH_2) group from the preceding member e.g. butyne is greater by a CH_2 than propyne and similarly, propyne is greater by a CH_2 group than ethyne.

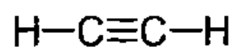
General formula:

The general formula of alkynes is C_nH_{2n-2} where "n" represents the number of carbon atoms.The first member of alkynes is ethynei.e. C_2H_2. Acetylene is the common name of ethyne.

Example

First four members of alkynes and their structural, dot and cross formulas are given below.

- EthyneC_2H_2

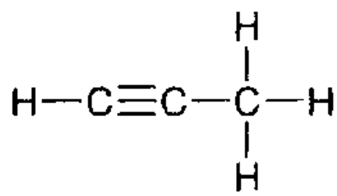


Structural formula

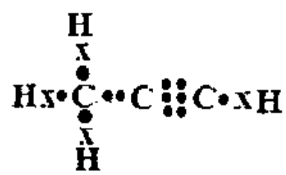


Electron dot and cross formula

- PropyneC_3H_4

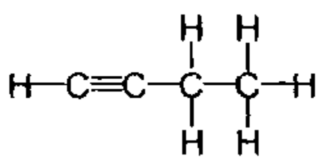


Structural formula

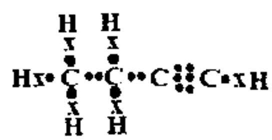


Electron dot and cross formula

- ButyneC_4H_6

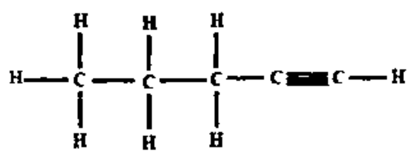


Structural formula

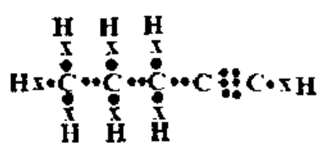


Electron dot and cross formula

- PenteneC_5H_{10}



Structural formula



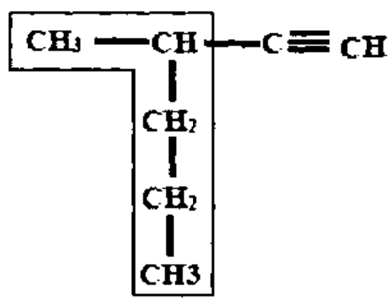
Electron dot and cross formula

Q.15 How alkynes are named according to IUPAC rules.

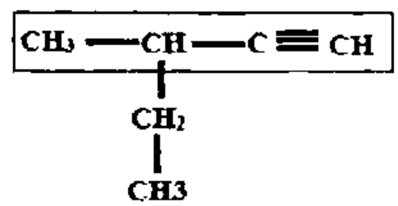
Ans. Basic rules of nomenclature for alkanes, alkenes and alkynes are same except some differences.IUPAC rules for naming alkynes are given below.

i. Selection of the longest continuous chain containing a triple bond

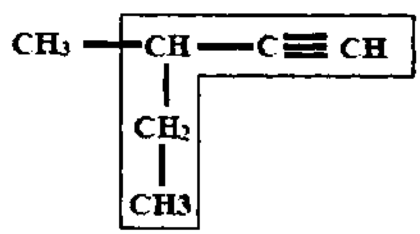
Examples



Wrong selection



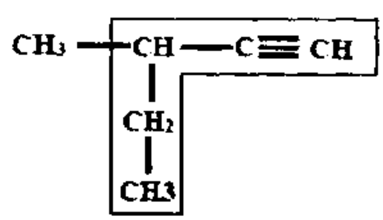
Wrong selection



Right selection

ii. The number of carbons in the longest chain will determine the parent name of alkyne. As we have five carbons in the given case so the parent name will be "pentyne" in this case.

Example



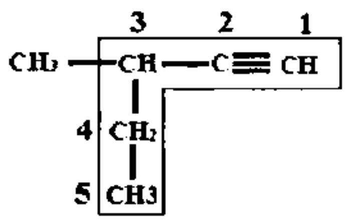
3-methyl-1-pentyne

iii. The "ane" of alkane will be replaced by "yne". e.g. pentyne for pentane

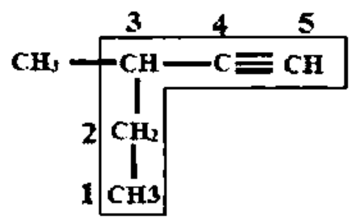
As given in example of step ii.

iv. Numbering from that end of the chain which is nearer to the triple bond.

Examples



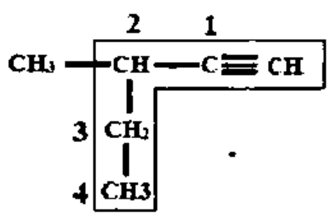
Right numbering



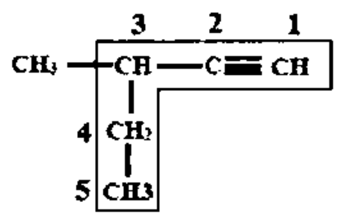
Wrong numbering

v. Numbering will be along the triple bond i.e. both carbon of the triple bond must be included in numbering.

Examples



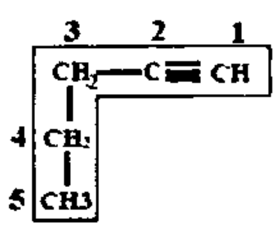
Wrong numbering



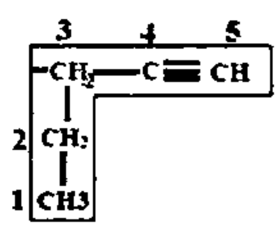
Right numbering

vi. Indication of the position of the triple bond with the lowest possible number.

Examples



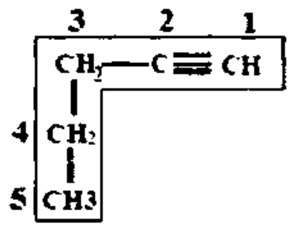
Correct name= 1-pentyne



Wrong name= 4-pentyne

vii. The number of the first atom of the triple bond will determine the position of the triple bond.

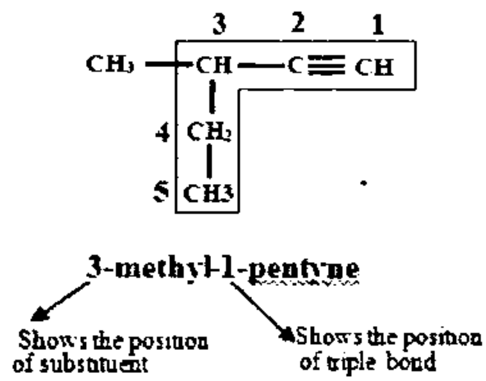
Example



Correct name = 1-pentyne , wrong name = 2-pentyne

viii. Indicate the position of the substituents by the number of the carbon atom to which they are attached.

Example



Q.16 Write down the preparation of alkynes.

Ans. Alkynes are prepared from saturated organic compounds by elimination reactions. In this way saturated organic compounds are converted to unsaturated organic compounds.

Eliminationreactionis that type of reaction in which atoms that are attached to adjacent atoms of a molecule are removed to form a double or triple bond. Elimination reaction

is opposite to addition reaction.

Some of the examples of elimination reactions that are used for the preparation of alkynes are given below.

Dehydrohalogenation of adjacent Dihalides

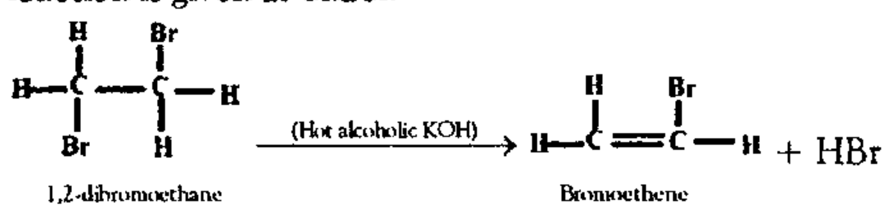
In dehydrohalogenation of adjacent di-halides, hydrogen and a halogen are removed from the adjacent carbons. The organic compounds in which dihalides are attached to the adjacent carbon atoms are called vicinal dihalides. This reaction occurs in two steps.

Step 1:

First step is the conversion of vicinal dihalide like 1,2-dibromoethane to bromoethene by heating 1,2-dibromoethane with alcoholic potassium hydroxide (KOH) solution. Hydrogen from one carbon atom and bromine from the adjacent carbon atomis removed and bromoethene along with the HBr is produced.

Chemical Reaction

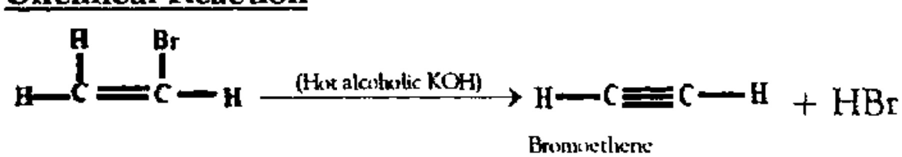
The reaction is given as under.



Step 2:

In the second step another HBr is removed from the bromethene formed in the first step thus leads to the formation of ethyne (common name acetylene).

Chemical Reaction

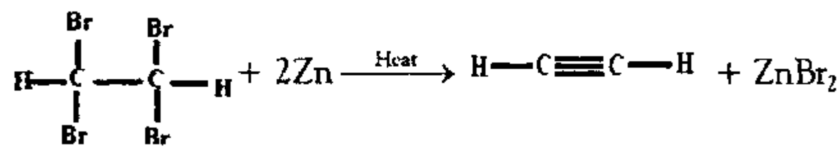


Dehalogenation of tetrahalides

Those compounds which contain four halogen atoms on the adjacent carbon atoms are called tetra halides. When tetrahalide like 1,1,2,2-tetrabromoethane is made to react with zinc (Zn) dust, the formation of ethyne takes place along with $ZnBr_2$.

Chemical Reaction

The reaction is given below.



Q.17 Write down the physical properties of alkynes.

Ans. Physical Properties of Alkynes

Physical State

Alkynes exist in all three states of matter. First three members of alkynes are gases. Next eight members are liquids while higher are solids.

Colour

Alkynes are colorless

Odour

All Alkynes areodourless except ethyne. Pure ethyne is also odour less. The ethyne commercially used is containing impurities which is responsible for its garlic like order.

Boiling Point and Melting Point

Boiling points of alkynes is greater than corresponding alkenes.The melting points and boiling points of alkynes increase with the increase in molecular mass.

Denisty

The densities of alkynes increase with the increase in

molecular mass.

Solubility

They are non-polar, therefore they are insoluble in water but soluble in organic solvents like benzene, acetone etc.

Inflammability

They release a huge amount of energy on complete combustion and produce carbon dioxide and water.

Q.18 Write down the important chemical reactions of alkynes. OR

Write the chemical properties of alkynes.

Ans. **Chemical Properties of Alkynes**

Alkynes are unsaturated hydrocarbons. They contain a triple covalent bond. The triple covalent bond comprises of one δ- bond and two π-bonds. As π-bonds are weak, which can be broken easily thus making alkynes more reactive (i.e. more reactive than alkanes and less reactive than alkenes). Alkynes undergo addition reaction in which they are converted to saturated hydrocarbons.Some of the addition reaction of alkynes is given below:

Halogenation

Addition of halogens like fluorine, chlorine, bromine etc., is called halogenation. Halogenation of alkynes occurs in the presence of phosphorus tri-chloride as a catalyst. The order of reactivity of halogens with alkynes is given below.

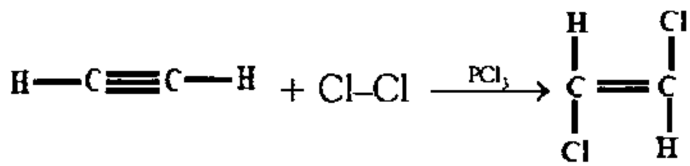
$Cl > Br > I$

Step I

The first step is the conversion of a triple bond to a double bond. It is the addition of a halogenmolecule like chlorine to the triple bond of alkyne like ethyne. The formation of 1,2-dichloroethene takes place in the first step.

Chemical Reaction

The reaction is given as under

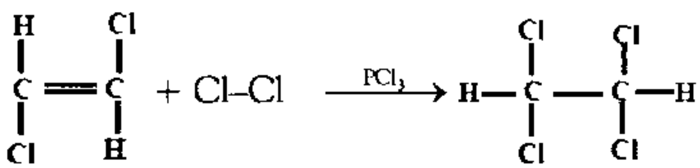


Ethyne 1,2-dichlorethene

Step II

The next step is the addition of another chlorine molecule to the double bond of 1,2-dichlorethene formed in the first step. As a result the double bond is converted to single bond and 1,1,2,2-tetra chloroethane is formed.

Chemical Reaction

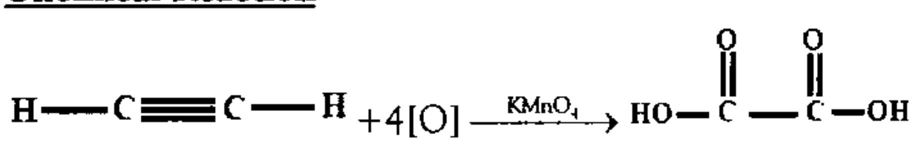


1,2-dichlorethene 1,1,2,2-tetra chloroethane

Oxidation of alkynes with $KMnO_4$

Oxidation of ethyne occurs in the presence of nascent oxygen [O] and potassium permanganate ($KMnO_4$). As a result, oxalic acid is produced.

Chemical Reaction



Oxalic acid

EXERCISE

A. Choose the correct option.

1. Which one of the following is a substitution reaction
   a. Halogenation of alkynes
   b. Halogenation of alkenes
   c. Halogenation of alkanes
   d. Oxidation ethene
2. When ethene reacts with HBr, the compound formed is
   a. CH_3-CH_2-Br b. $Br-CH_2-CH_2-Br$
   c. $CH_3-CH_2-CH_3$ d. $CH \equiv CH$
3. Halogenations of methane in the presence of diffused sunlight occurs
   a. Quickly, only in one step b. Slowly, only in one step
   c. In a series of four steps d. Quickly, in two step
4. Dehydrohalogenation of alkylhalide is
   a. Removal of hydrogen b. Removal of halogen
   c. Removal of hydrogen and halogen
   d. Addition of hydrogen and halogen
5. Which one of the following decolourises Br_2 water
   a. Ethane b. Ethene
   c. Propane d. Methane
6. The general formula of alkane is
   a. C_nH_{2n} b. $C_nH_{2n\times 2}$
   c. C_nH_{2n+2} d. C_nH_{2n-2}

7. Dehydration of ethyl alcohol with conc. H_2SO_4 results in the formation of
   a. Ethane b. Methane
   c. Ethyne d. Ethene
8. Substitution reaction is the characteristics of
   a. Alkynes b. Alkenes
   c. Alkanes d. None of these
9. Which one is the least reactive,
   a. Ethyne b. Propene
   c. Ethene d. Ethane
10. The order of reactivity of hydrogen halides with alkenes is
   a. HI>HCl>HBr b. HI>HBr>HCl
   c. HCl>HBr> HI d. HI<HBr<HCl

ANSWERS:

1	c	2	a	3	c	4	c	5	b
6	c	7	d	8	c	9	d	10	b

B. Write short answers to the following questions.

Q.1 How would you test that alkenes undergo addition reaction?

Ans. See Question 12

Q.2 Which one is more reactive Alkane or Alkene?

Ans. Alkanes are less reactive than alkenes because they have C –C and C–H single covalent bonds. Also the electronegativity of carbon and hydrogen is almost similar which makes the C-H bond more stable. Therefore, for a reaction to take place, an appreciable

amount of energy is required for breaking these bonds.Under certain conditions, they undergo substitution reactions only.

On the other hand, alkenes contain a double covalent bond i.e. a δ- bond and a π-bond. Breaking a π-bond requires less energy than a δ- bond which makes alkenes more reactive than alkanes. In other words, the π-electrons of the double covalent bond are readily available for an addition reaction to takes place, thus we can say that, the π-electrons are responsible for the reactivity of alkenes.

Q.3 Justify alkenes and alkenes as unsaturated hydrocarbons.

Ans. Alkenes are unsaturated hydrocarbons because they contain a double covalent bond. A carbon atom can form maximum four bonds with four other atoms, and the presence of double bond means it is bonded with threeother atoms, thus, unsaturated.

They can undergo addition reactions like

- Hydrohalogenation (addition of hydrogen halides)
- Hydrogenation
- Oxidation

Similarly, alkynes are unsaturated hydrocarbons due to the presence of a triple covalent bond.

Theycan undergo addition reaction like

- Hydrogenation
- Halogenations
- Oxidation with $KMnO_4$

Q.4 Why Alkanes are inert in nature?

Ans. Alkanes are inert in nature because they have C–C

and C–H single covalent bonds. These bonds are strong i.e. sigma(δ) bonds and are difficult to break. In addition, the electronegativity of carbon and hydrogen is almost similar which makes the C–H bond more stable. Thus, we can say that alkanes are inert in nature. Under certain conditions, they undergo substitution reactions only.

Q.5 What happens when alkyl halide is reduced?

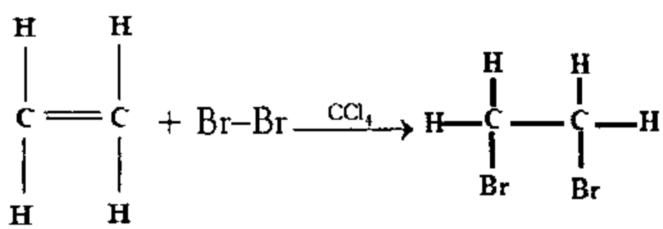
Ans. See Question 4 (Topic: Reduction of Alkyl halides)

Q.6 Can you predict the product if $KMnO_4$ solution reacts with alkenes?

Ans. See Question 11 (Topic: Oxidation with $KMnO_4$)

Q.7 Why the colour of bromine water discharges on addition to ethene?

Ans. Bromine is a reddish brown color liquid, when it is added to an alkene like ethene in the presence of an inert solvent like carbon tetra chloride (CCl_4), the reddish brown color of bromine disappears due to the formation of a colorless liquid known as 1,2-dibromoethane.



Ethene Bromine 1,2-dibromoethane

Reddish brown Colorless liquid

Q.8 Compare the reactivity of alkane and alkene.

Ans. A comparative study of the reactivity of alkanes and alkenes show that alkanes are less reactive than

alkenes because alkanes have C–C and C–H single covalent bonds (sigma(δ) bonds). Also, the electronegativity of carbon and hydrogen is almost similar which makes the C-H bond more stable. These bonds are strong and for a reaction to take place, an appreciable amount of energy is required for breaking these bonds. Therefore, alkanes are less reactive than alkenes.

On the other hand, alkenes contain a double covalent bond i.e. a δ- bond and a π-bond. As electrons in a π-bond are loosely held,breaking a π-bond requires less energy than a δ- bond which makes alkenes more reactive than alkanes. In other words, the π-electrons of the double covalent bond are readily available for an addition reaction to takes place, thus we can say that, the π-electrons are responsible for the reactivity of alkenes.

Q.9 Why addition reactions take place in ethene and ethyne but not in ethane?

Ans. Addition reactions take place in ethene and ethyne because they are unsaturated hydrocarbons. Unsaturated hydrocarbons are those hydrocarbons, which contain at least one double or triple covalent bond in between two carbon atoms i.e. the carbons containing the double or triples bonds are not bonded to four other atoms, thus, they are capable of adding more atoms. Ethene has a double covalent bond, one is δ-bond and the other one is π-bond. Ethyne has a triple covalent bond, one is δ-bond and the other two are π-bonds. All δ-bonds are stronger than π-bonds. In an addition reactions π -bonds are converted to δ-bonds thus making the compound more stable.In ethane all the bonds are δ-bonds and it has already

attained stability therefore it does not undergo addition reaction.

Q.10 Writeequation for the preparation of ethene from ethyl alcohol and ethyle chloride.

Ans. See Question 9

C. Write detailed answers to the following questions.

Q.1 i.Write down the preparation of alkanes, alkene, and alkynes.

Ans. See Question 4, 9 and 14

ii. Draw the molecular, dot and cross, condensed formula and structural formula of each of the following.

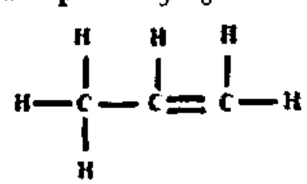
a. Propene b. butyne c. pentane

d. heptyne e. butane

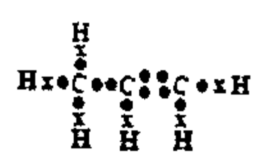
Ans.

Name of compound	Molecular formula	Condensed formula
Propene	C_3H_6	$(CH_2)_3$
Butyne	C_4H_6	$CH\equiv C-CH_2-CH_3$
Pentane	C_5H_{12}	$CH_3(CH_2)_3CH_3$
Heptyne	C_7H_{12}	$CH\equiv C-(CH_2)_4-CH_3$
Butane	C_4H_{10}	$CH_3(CH_2)_2CH_3$

- PropeneC_3H_6

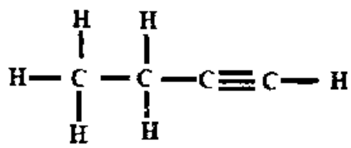


Structural formula

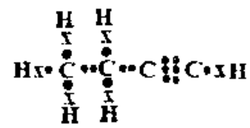


Electron dot and cross formula

Butyne

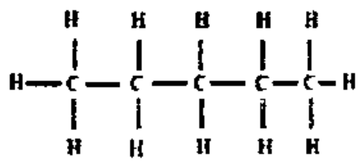


Structural formula

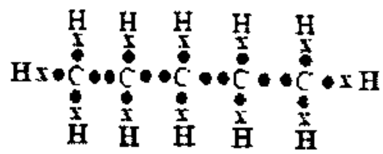


Electron dot and cross formula

Pentane

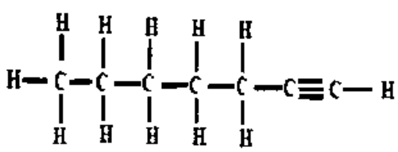


Structural formula

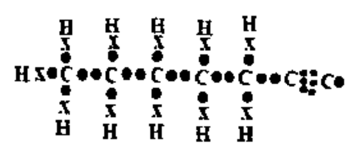


Electron dot and cross formula

Heptyne

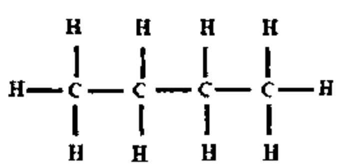


Structural formula

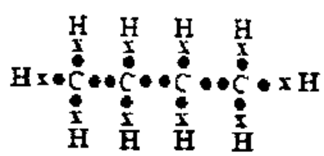


Electron dot and cross formula

Butane



Structural formula



Electron dot and cross formula

Q.2 (i) The general formula of alkanes is C_nH_{2n+2}. Determine the general formula of Cycloalkanes.

Ans. Cycloalkanes have two hydrogens less than alkanes therefore the general formula of alkanes will become C_nH_{2n}.

ii. Write a balanced equation for the complete combustion of each of the following:

a. Methane b. Ethene c. Ethyne

a. $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$ + Heat

b. $C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 2H_2O$ + Heat

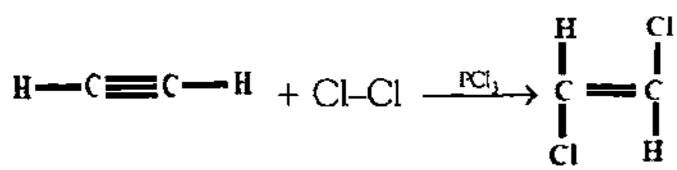
c. $2C_2H_2 + 5O_2 \longrightarrow 4CO_2 + 2H_2O$ + Heat

iii. Explainwhy ethyne undergoes addition reaction in two steps?

Ans. As ethyne is an unsaturated hydrocarbon that contains a triple bond therefore it undergoes addition reaction in two steps.

Step I

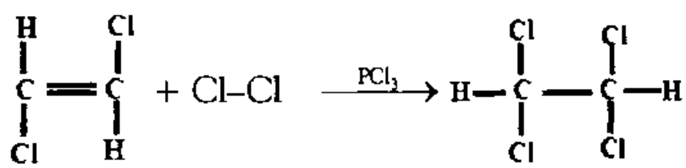
The first step is the conversion of a triple bond to a double bond. It is the addition of a halogen molecule like chlorine to the triple bond of alkyne like ethyne. The formation of 1,2-dichloroethene takes place in the first step. The reaction is given as under



Ethyne 1,2-dichlorethene

Step II

The next step is the addition of another chlorine molecule to the double bond of 1,2-dichlorethene formed in the first step. As a result, the double bond is converted to single bond and 1,1,2,2-tetra chloroethane is formed.



1,2-dichlorethene 1,1,2,2-tetra chloroethane

Q.3 (i) Give an example reaction that would yield the following products. Name the organic reactants and products in each case.

a. Alkane

b.Monohalogenated alkane

c. Dihalogenated alkane

d. tetrahalogenated alkane

Ans. a. Alkane

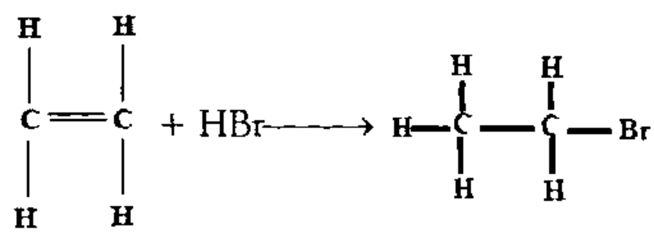
Alkanes are produced by hydrogenation of ethene. The reaction is given below.

$$H_2C{=}CH_2 + H_2 \xrightarrow[250^\circ C-300^\circ C]{Ni/Pt} H_3C{-}CH_3$$

Ethane

b.Monohalogenated Alkanes

Monohalogenated alkanes (simple alkyl halides) are formed when hydrogen bromide (HBr) reacts with ethene and as a result bromoethane is formed which is a monohalogenated alkane.

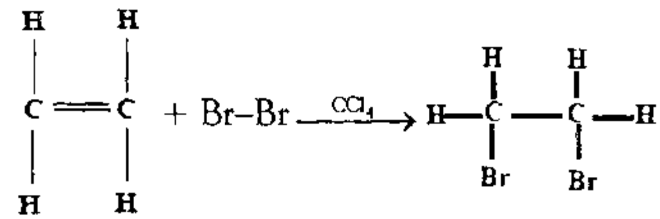


Ethene Bromoethane or Ethyl bromide

(amonohalogenated alkane)

c. Dihalogenated alkane

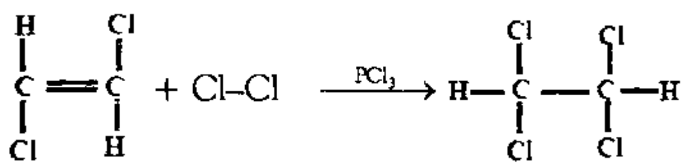
Bromine is a reddish-brown color liquid, when it is added to ethene in the presence of an inert solvent like carbon tetra chloride (CCl_4), a dihalogenated alkane like 1,2-dibromoethane is formed.



Ethene — Bromine, Reddish brown — 1,2-dibromoethane, Colorless liquid (A dihalogenated alkane)

d. Tetrahalogenated alkane

When a chlorine molecule is added to the double bond of 1,2-dichlorethene ,the double bond is converted to single bond and a tetra-halogenated alkane like 1,1,2,2-tetra chloroethane is formed.



1,2-dichlorethene — 1,1,2,2-tetra chloroethane

Q.3 (ii) a. Alkenes are unsaturated hydrocarbons. Explain the word unsaturated.

Ans. Alkenes are unsaturated hydrocarbons because they contain at least one double covalent bond. The word unsaturated means that the valency of carbon is not fully satisfied. They have the ability to adjust two more atoms across the double bonds. Alkenes are generally made saturated by hydrogenation reaction. Addition of hydrogen across the double bond of alkenes in the presence of Nickle or Platinum as a catalyst and 250°C-300 °Ctemperature is called hydrogenation of alkenes. The reaction is given below.

$$H_2C{=}CH_2 + H_2 \xrightarrow[250^\circ C-300^\circ C]{Ni/Pt} H_3C{-}CH_3$$

b. Describe the bonding between the two carbon atoms in ethene.

Ans. There is a double covalent bond between the two carbon atoms of ethene. One is sigma (δ)-bond and the other is pi(π)-bond. Sigma(δ)-bond is strong bond and pi(π)- bond is weak bond.The presence of pi-electrons in pi-bond makes ethene more reactive. The pi-bond is weak and can be broken easily which facilitates addition reactions in ethene.

c. Which functional group is present in ethene?

Ans. Single bond, double bond,triple bond or an atom or group of atoms, which gives specific characteristics to an organic compound, is called functional group. As the double bond present in alkene gives specific characteristics to alkene, therefore the functional group of alkenes is Double Bond.

d. Describe a simple chemical test to determine whether an unknown hydrocarbon is unsaturated. Describe the result if the test is positive.

Ans. See Question 12

Q.4 Using structural formula, give balanced equations for the following reactions.

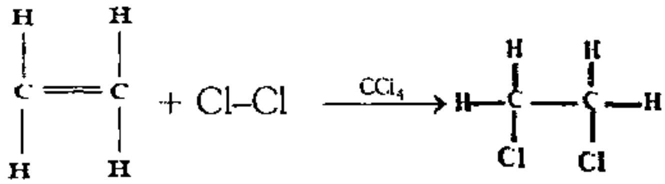
a. Ethene with chlorine

b. Ethene with hydrogen. Name the catalyst used. Which industrial process uses a similar reaction?

c. Ethenewith hydrogen bromide

d. Ethenewith $KMnO_4$

Ans. a. Ethene with Chlorine



1,2-dichloroethane

b. Ethene with hydrogen

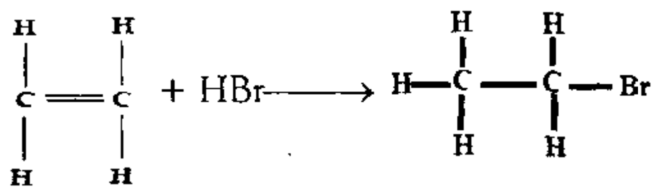
The reaction of hydrogen with ethene is called hydrogenation. The reaction is given as under

$$H_2C=CH_2 + H_2 \xrightarrow[250^\circ C-300^\circ C]{Ni/Pt} H_3C-CH_3$$

Hydrogenation is industrially used for the conversion of unsaturated vegetable oils intosaturated hydrocarbons like Ghee

c. Ethene with hydrogen bromide

When hydrogen bromide HBr reacts with ethene ethyl bromide is formed



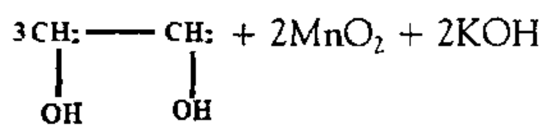
Ethene Bromoethane or Ethyl bromide

d. Ethene with $KMnO_4$

Ethene reacts with acidified potassium permanganate to form glycol.

$$3H_2C=CH_2 + 2KMnO_4 + H_2O \xrightarrow{Acid}$$

Ethene Potassium permanganate



Ethylene glycol Manganesedioxide PotassiumHydroxide

Q.5 Illustrate the following accordingly as been instructed.

a. Alkane from Alky Halide

b. Bromoethane from ethene

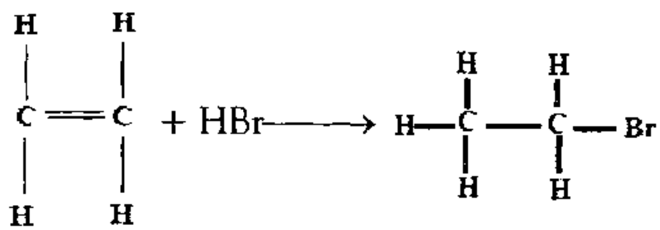
c.Ethylene glycol (1,2-ethanediol) from ethene

d. Ethynefrom tetrahalides

e. Oxalic acid from acetylene

Ans. a. See Question 4 (Reduction of alkyl halides)

b. Bromoethane is formed when hydrogen bromide (HBr) reacts with ethene.



Ethene Bromoethane

c. Ethylene glycol (1,2-ethanediol) is formed whenethen.. reacts with acidified potassium permanganate $KMnO_4$.The reaction is given below

$$3H_2C{=}CH_2 + 2KMnO_4 + H_2O \xrightarrow{Acid}$$

Ethene Potassium permanganate

$$3\underset{\displaystyle OH}{\underset{|}{CH_2}}-\underset{\displaystyle OH}{\underset{|}{CH_2}} + 2MnO_2 + 2KOH$$

Ethylene glycol Manganesedioxide PotassiumHydroxide

d. See Question 16
(Topic: Dehalogenation of tetrahalides)

e. See Question 18
(Topic: Oxidation with $KMnO_4$)

Unit 13

Biochemistry

Q.1 Define Biochemistry. What are biological molecules? Also write the names of some biological molecules

Ans. **Biochemistry**

It is the branch of chemistry which deals with study of organic compounds and reactions that occur in living organisms.

OR

The study of biology under the principles of chemistry is called biochemistry.

It is a sub discipline of biology and chemistry.

Biological Molecules

As we know that, all living organisms are made up of cells.

Cells contain both organic compounds and inorganic compounds.

The organic compounds, which build up the whole body of living organisms, are known as biological molecules.

Biological molecules are

- Carbohydrates
- Proteins
- Lipids
- Nucleic acids
- Vitamins

These biological molecules constitute various parts or organelles of a cell e.g.

- The cell wall of plant cell is made up of cellulose, which is a carbohydrate.

- The cell membrane is made up of protein and lipids.
- Chromosomes present inside the nucleus are made up of proteins and nucleic acids.

Q.2 What are carbohydrates?

Ans. **Carbohydrates**

Definition

Carbohydrates are macromolecules of polyhydroxy aldehydes and ketones. Carbohydrates are also known as saccharides. "Saccharum" is a Latin word which means sugar.

Composition

Carbohydrates are generally composed of carbon, hydrogen and oxygen in the ratio of 1:2:1 respectively. Sometime carbohydrates may contain elements other than carbon, hydrogen and Oxygen. For example, Chitin contains nitrogen. Chitin is a carbohydrate that makes the cell wall of fungi.

Carbohydrates often have the following three groups

- A hydroxyl group –OH
- An Aldehyde group –CHO
- A Keto group (ketones) –CO–

General Formula

Carbohydrates have a general formula of $C_n(H_2O)_n$, where "n" is equal to 3 or greater than 3.

Examples

Some of the examples are Glucose, fructose, sucrose, starch etc.

- Glucose is present in grapes sugar
- Fructose is present in honey
- Sucrose is present in cane sugar

- Starch is present in potatoes

Q.3 How can we classify carbohydrates?

Ans. Classification of Carbohydrates

Carbohydrates are long chains of simple sugars units.

They are classified in to three classes on the bases of number of simple sugar units present per molecule i.e.

- Monosaccharide
- Oligosaccharides
- Polysaccharides

The three classes of carbohydrates are described below in detail.

Monosacchartaide

- ➢ They are the simplest sugars.
- ➢ They are the basic units of carbohydrates.
- ➢ They cannot be hydrolyzed into more simple sugars.
- ➢ Hydrolysis is the splitting of a biological molecule due to its reaction with water.

General formula

General formula of monosaccharide is $C_n(H_2O)_n$, where "n" ranges from 3 to 9.

Thus, those carbohydrates will be monosaccharide, which contain 3 to 9 carbon atoms.

Physical properties

Physical State

They are crystalline solids at room temperature.

Taste

Monosaccharides are sweet in taste e.g. fructose is 73% sweeter than sucrose.

Colour

They are colorless crystalline solids.

Solubility

They are soluble in water due to the presence of large number of OH groups.

Classification and examples of monosaccharides

Monosaccharides are further classified into:

Trioses

Those monosaccharides, which contain 3 carbons are called trioses.

For example Glyceraldehyde ($C_3H_6O_3$)

Tetroses

Those monosaccharides, which contain 4 carbons are called tetroses.

For example erythrose ($C_4H_8O_4$)

Pentoses

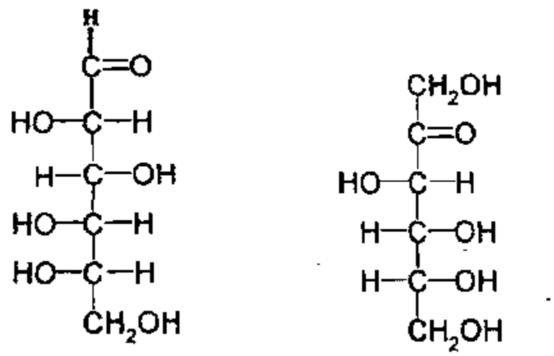
Those monosaccharides, which contain 5 carbons are called pentoses.

For example Ribose ($C_5H_{10}O_5$)

Hexoses

- Those monosaccharides, which contain 6 carbons are called hexoses.
- For example Glucose, galactose and fructose ($C_6H_{12}O_6$)
- They have the same molecular formulabut different structural formula.
- Glucose and Galactose are aldose sugar while fructose is ketose sugar.
- Glucose is a pentahydroxy aldehyde containing five-hydroxyl groups and an aldehydic functional group.
- Fructose is a pentahydroxy ketone containing five-

hydroxyl group and a ketonic functional group.



Glucose Fructose

Oligosaccharides

Those carbohydrates, which give 2 to 9 units of simplesugars (monosaccharides) on hydrolysis, are called oligosaccharides

Classification of Oligosaccharides

- They are classified into disaccharides, trisaccharides, tetrasacharides etc.
- Disaccharides produce two monosaccharide units on hydrolysis.
- Trisaccharides produce three monosaccharide units on hydrolysis.
- Tetrasaccahride produce four monosaccharide units on hydrolysis and so on.

Physical properties

Physical state

Oligosaccharides are white crystalline solids. (Crystalline solids are those substances which have a specific geometry at microscopic level)

Taste

They are sweet in taste.

Colour

They are colourless.

Solubility

They are soluble in water.

Examples

Disaccharide:

- Sucrose, maltose and lactose ($C_6H_{12}O_6$) are examples of disaccharides.
- They have the same molecular formula but different structural formula.

Trisaccharides:

- Raffinose and maltotriose ($C_{18}H_{32}O_{16}$) are examples of trisaccharides.
- They have the same molecular formula but different structural formula.

Tetrasachharides:

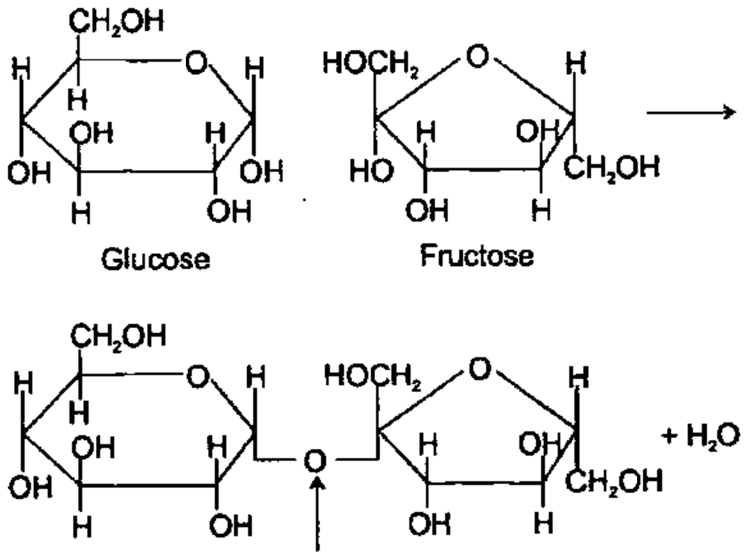
- Stachyose and nystose ($C_{24}H_{42}O_{21}$) are examples of tetrasacharides.
- They have the same molecular formula but different structural formula.

Hydrolysis

The splitting of a biological molecule by water into two or more simple units is called hydrolysis. The hydrolysis of sucrose, maltose and lactose into simple sugars(monosaccharides) is given below.

Hydrolysis of Sucrose

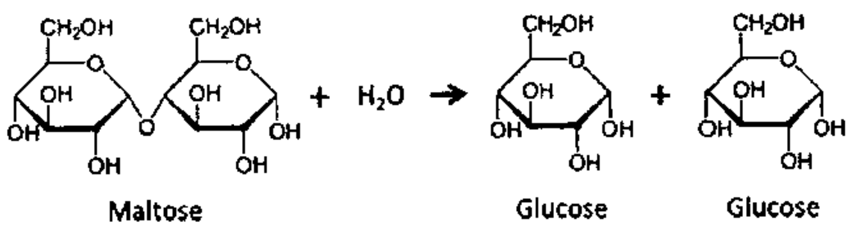
$$\text{Sucrose} \xrightarrow{\text{water}} \text{Glucose} + \text{Fructose}$$



Glycosidic linkage
Sucrose

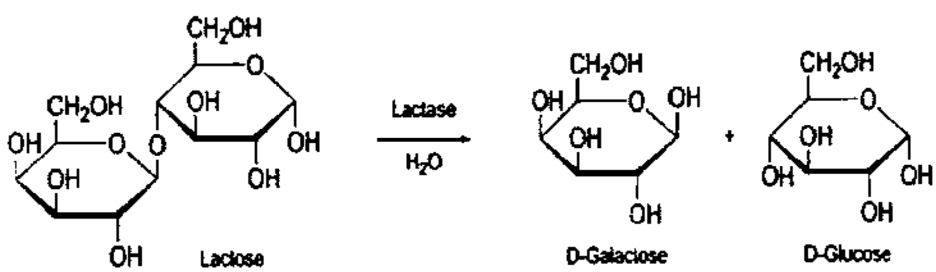
Hydrolysis of Maltose

$$\text{Maltose} \xrightarrow{\text{water}} \text{Glucose} + \text{Glucose}$$



Hydrolysis of Lactose

$$\text{Lactose} \xrightarrow{\text{water}} \text{Glucose} + \text{Galactose}$$



Polysaccharides

Definition

Those carbohydrates, which consist of long chains of monosaccharide units bonded together by glycosidic linkage, are called polysaccharides.

- Monosaccharide units mean simple sugars containing only 3 to 9 carbon atoms.
- Glycosidic linkage is the bond of one simple sugar unit with another unit.
- Polysaccharides are biopolymers of monosaccharides.
- A polymer is a large molecule, composed of many repeated subunits.
- Biopolymer is a polymer of biological molecules like carbohydrates, proteins, nucleic acids etc.
- Biopolymers are also known as macromolecules as they are long chains of repeated units having high molecular mass.
- They give many molecules of monosaccharides on hydrolysis.

Physical properties

Physical state

They are amorphous solids. (Those substances, which have an irregular geometry at microscopic level)

Taste

They are also known as non-sugars because they are tasteless.

Solubility

They are insoluble in water.

Molecular Mass

They have high molecular mass and consist of 100 or more monosaccharides units.

Examples

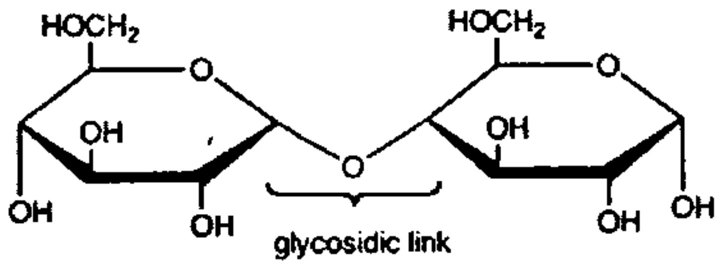
Starch, Glycogen and cellulose are examples of polysaccharides.

Q.4 Define Glycosidic linkage. Give example.

Ans. Glycosidic linkage/Glycosidic bond

The type of covalent bond that joins a simple sugar molecule of a carbohydrate to another sugar molecule is called glycosidic bond or glycosidic linkage. A glycosidic linkage is a link between the rings of simple sugars (monosaccharides) of carbohydrates.

Example



Q.5 Write down the sources of carbohydrates.

Ans. Important sources of carbohydrates are given below.

Sources of monosaccharides:

Monosaccharides are found in fruits, vegetables, cereals, honey etc.

(Grains used for food such as wheat, grains etc are called cereals)

Sources of Oligosaccharides

- Sucrose, maltose and lactose are disaccharides. Disaccharides are example of oligosaccharides.
- Sucrose is found in sugarcane, sugar beet and fruits like pineapple, mango etc.
- Lactose is found in milk and dairy products.

- Maltose is found in cereals.

Sources of Polysaccharides

- Cellulose and starch are examples of polysaccharides.
- Cellulose is found in plants like cotton etc.
- Starch is found in cereal for example wheat,barley, maize, rice etc.

Q.6 Write down the uses of carbohydrates.

Ans. Uses of carbohydrates

- They are used as instant source of energy.
- They are used as source of food.
- Sugar is carbohydrate that is used as sweetener for food.
- Cellulose helps in lowering cholesterol and regulates blood pressure.
- Glucose is stored in the form of glycogen in the body for long term use.
- Cellulose is used to make paper.
- Cloths are made up of cellulose.
- Dietary fibers are carbohydrates that controlled constipation and diarrhea.

Q.7 What are proteins?

Ans. Definition

The word protein is derived from a Greek word "proteios" which means "of prime importance."

- They are biopolymers of amino acids.
- Amino acid is the building block of proteins.

Peptide bond

The bond, which links two amino acids with one

another is called peptide bond.

Thus, we can say that proteins are polypeptide chains of amino acids, as many amino acids join togetherto form proteins.

Composition

They are highly complex nitrogenous substances. They contain carbon, hydrogen, oxygen, nitrogen. Some proteins contain sulphur also.

Hydrolysis

The splitting of a biological molecule by water into two or more simple units is called hydrolysis. Hydrolysis of proteins gives amino acids.

Bonding

There are three types of bonding in protein molecules:

- Peptide bonding
- Hydrogen bonding
- Disulphide bridges

Disulphide bridges are found in sulphur containing proteins only.

Hydrogen bonding and disulphide bridges are responsible for the secondary, tertiary and quaternary structures of proteins.

Importance

- Proteins are the major part of cells.
- They are essential for growth and development.
- Most of the body functions are controlled by proteins e.g. most of the enzymes are proteins.
- 50 to 55 % dry weight of cell is due to proteins.
- Chromosomes that play important roles in genetic variation and continuity of life are made upof proteins

and nucleic acids.

Example

Albumin (present in egg white), Legumin (in beans, peas),Collagens and Keratin (in skin, hair, nails etc.) are examples of proteins.

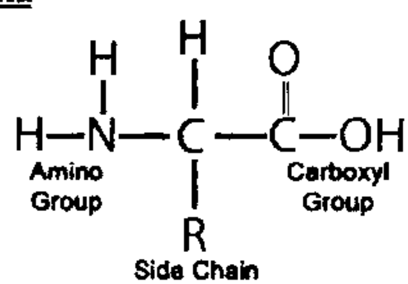
Q.8 What are amino acids? What are essential and non-essential amino acids?

Ans. Amino Acids

Those organic compounds, in which both amino group (NH_2) and carboxyl group (COOH) attached to the same alpha carbon, are called amino acids. Amino acids are mostly composed of Carbon, hydrogen, oxygen, nitrogen and sometimes they may have sulphur also.

Amino acids are the building blocks of proteins.

Structural formula



Amino acids are of twenty types, each containing a different alkyl group. Out of these twenty amino acids nine (9) are essential amino acids while eleven are non-essential amino acids.

Essential amino acids

Those amino acids, which, cannot be prepared by our body, are called essential amino acids. They must be taken in diet.

Non-essential amino acids

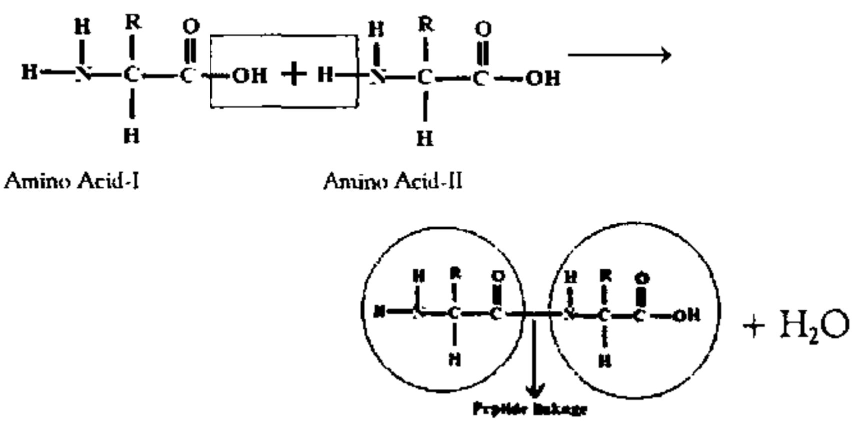
Those amino acids, which can be prepared by our body

are called non-essential amino acids.

Condensation Reaction

A condensation reaction is a reaction in which two molecules combine to form a large molecule along with the removal of a small molecule. Condensation reaction is opposite to hydrolysis reaction.

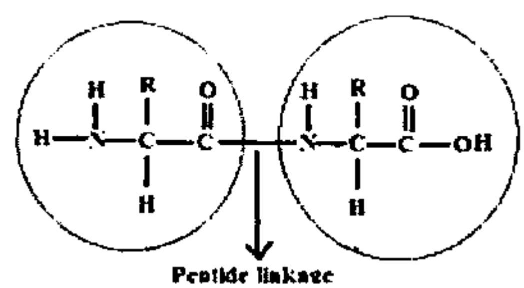
Condensation reaction among amino acids produces a long chain of proteins along with the removal of water molecules.



Peptide linkage

The linkage between the carbonyl carbons of one amino acid with the nitrogen of amino group, of another amino acid is called peptide linkage or peptide bond. This linkage forms when "OH" (hydroxyl) of carboxyl group (-COOH-)of one amino acid combines with "H" (hydrogen) of amine group (-NH_2-) of other amino acid, and water is formed.

Representation of peptide bond



Q.9 Mention the major sources of proteins/amino acids.

Ans. Sources of proteins/amino acids

Proteins are found in different foods. Proteins are derived from both plant sources and animal sources.Proteins obtained from animal sources are of high biological value than proteins obtained from plants.

Plant Sources of proteins are legumes, grains, nuts, seeds, vegetables etc.

Animal sources of proteins are fish, meat, eggs, milk cheese, yogurt, poultry etc.

Q.10 Write down the uses of proteins

Ans. Uses of proteins

Proteins are of prime importance for our body. Proteins control most of the activities occurring in a cell. They perform the following functions.

As oxygen carrier

Hemoglobin is a protein, which is present in the blood. It transports oxygen to all parts of our body.

As Food

Proteins are used as food because it is needed for the formation of protoplasm and various components of cells.

Body structure

The skin, nails, hair, hoofs horns and feather are made up of keratin, which is a type of protein.

Growth

Proteins play important role in physical and mental growth.

As enzymes

All enzymes are proteins in nature. Enzymes are biological catalyst that speeds up the chemical reactions

occurring inside the body of a living organism.

Commercial uses of enzymes (proteins)

Enzymes improve the quality of textile, detergents, food and beverages. They also help in the formation of vinegar and cheese.

As Body Regulators

Proteins regulates all the activities and chemical processes occurring inside the body.

As Antibodies

Antibodies present in our body are also proteins. They protect our body against diseases.

Other uses

Animal hides are protein in nature. They are used for making leather. Leather is used for making various products like shoes, jackets etc.

Q.11 Write note on Lipids.

Ans. **Lipids**

Definition

Lipid is a Greek word, which means fats. It can be definedas "those substances which are insoluble in water but soluble in non-polar solvents like alcohol, ether and chloroform."

Sources

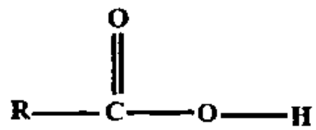
These substances are obtained from plants and animal tissues.

Composition

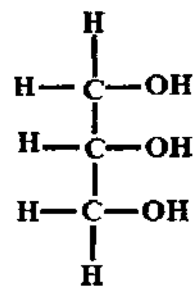
Lipids are esters of long chain fatty acids. As these esters are made up of three fatty acids molecules therefore they are also known as triglycerides.

Building blocks of lipids

The building blocks of lipidsare triglycerides. Triglycerides are formed by the condensation reaction of fatty acids(R-COOH) and glycerol.

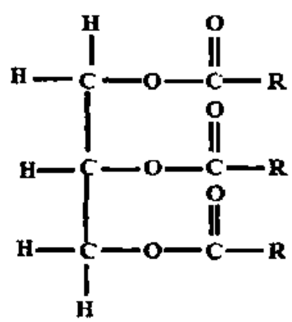


Fatty acids



Glycerol

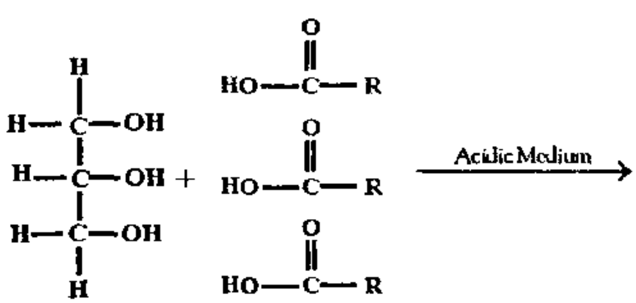
General formula

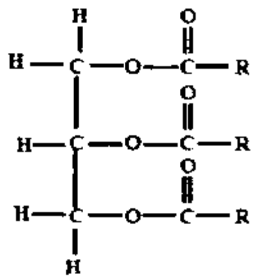


Triglyceride

Condensation reaction

The condensation reaction of glycerol and fatty acids give triglycerides with the removal of water molecules.





$+ \quad 3H_2O$

Types of lipids

Types of lipids are given below:

Fats and oil, Steroids, Turpentine oil, Phospholipids of cell membrane, Sex hormones, Waxes, Vitamins like A,D,E and K

Q.12 How can we classify lipids?

Ans. Classification of Lipids

Lipids are classified into two main types i.e.

- Simple lipids
- Complex lipids

Simple lipids

Simple lipids are also known as triglycerides.Simple lipids yield fatty acids and alcohol.Fats, oils and wax are examples of simple lipids.

Complex lipids

Those lipids, which produce fatty acids, alcohols and some other substances on hydrolysis, are known as complex lipids. Complex lipids are further classified into the following types.

Phospholipids:

Those lipids,which contain phosphate group in addition to fatty acids and glycerol.

Glycolipids:

Those lipids which are attach to carbohydrates by

glycosidic bond.

Sulpholipids:

Lipids possessing a functional group that contains sulphur

Q.13 What are fatty acids? Define saturated fatty acids and unsaturated fatty acids also.

Ans. Fatty acids

- Fatty acids are carboxylic acids, which contain long aliphatic chain of an alkyl group.
- The alkyl group may be saturated or unsaturated.
- Fatty acids containing C-C single bonds are called saturated fatty acids.
- Fatty acids containing C-C double bonds are called unsaturated fatty acids.
- Fatty acids containing more than one double bond are called polyunsaturated fatty acids.

Examples of polyunsaturated fatty acids

- Stearic acid $C_{17}H_{35}COOH$ found in animals.
- Butyric acid C_3H_7COOH found in animal fats and plants oils.
- Caproicacid $C_5H_{11}COOH$ found in butter, cheese and coconut oils.

Q.14 What is the difference between fats and oils?

Or Distinguish between fats and oils.

Ans. Fats and oils are chemically similar in nature because

- They both are tri-esters.
- They both are formed from fatty acids and glycerol.
- The difference between fats and oils is in the aliphatic carbon chain.

Fats

- Those triglycerides in which long chain saturated fatty acids arein higher proportion.
- Fats are mostly present in animals.
- They are solids or semisolids at room temperature.
- Saturated fatty acids have high melting point and are solid at room temperature as observed in bee wax.

Example

- Palmitic acid, which is found in Palm oil.
- Cream, cheese, butter, milk, dairy products and fatty meats.
- Coconutoil

Oils

- Those triglycerides in which long chain unsaturated fatty acids are in higher proportion.
- They are liquid at room temperature.
- They are present in plants and fishes.
- Unsaturated fatty acids have low melting point and are liquid at room temperature as observed in mustard oil, olive oil, soybean oil etc.

Examples

- Oleic acid found in animals and vegetable fats and oils
- Gadoleic acid found in cod liver oils (cod is a type of fish).

Q.15 How are oils converted into Ghee?

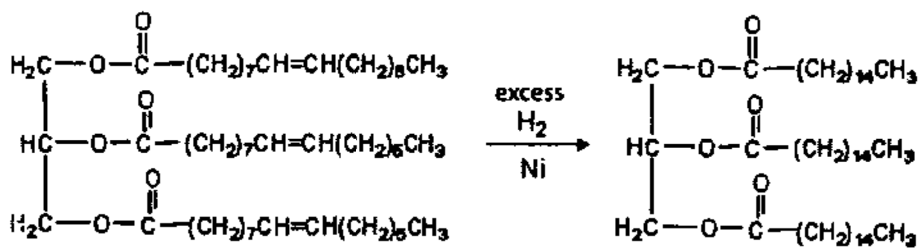
OR What do you mean by catalytic hydrogenation of oils?

Ans. Catalytic hydrogenation is a process in which unsaturated hydrocarbons are reduced to saturated

hydrocarbons in the presence of Ni as a catalyst and at a temperature 250°C-300°C.

As we know that, oils have polyunsaturated hydrocarbons chains while ghee has saturated hydrocarbon chains. Thus, by the process of catalytic hydrogenation the polyunsaturated hydrocarbon chains of oils are converted to saturated hydrocarbon chains to form ghee (fats).

Chemical reaction



Oil (unsaturated) Fat (Saturated)

Q.16 Write down the sources of lipids.

Ans. Sources of lipids

Lipids are obtained from a variety of sources like

- Plants
- Animals
- Marine organisms

Plants sources

- Plants are rich sources of vegetable oils.
- Plants like sunflower, corn, cotton, peanut, groundnut, walnut, coconut etc., are good sources of lipids.

Animals sources

- Milk is a rich source of fats.
- Butter, ghee, cheese etc., are rich sources of lipids, which are all obtained from milk.

Marine sources

- Salmon is a marine fish which is a rich source of lipids.
- Whale is a marine mammal and is also a rich source of lipids.
- Cod liver oil is derived from the liver of cod fish. It is used as a dietary supplement.

Q.17 Write down the uses of lipids.

Or How are lipids important to our body?

Ans. Uses of lipids

Lipids are important to our body because our body uses them in the following ways.

Energy source

- They are used as energy resources.
- Energy is stored in the form of fats for long-term use.
- They contain two times more energy than carbohydrates and proteins.

Thermalinsulator

- The layer of fats presents underneath the skin of mammals act as thermal insulator.
- They protect them from excessive heat and cold.

Shock absorber

- Important organs of our body for instant heart,kidneys etc., are surrounded by a layer of fats.
- This layer of fats minimizes the impacts of external shocks.

Solvent

Vitamins like A,D,E and K are important biomolecules which are not soluble in water, but they are soluble in fats.

Thus, fats act as a solvent for such kind of vitamins.

Integral part

Lipids are integral part of protoplasm and plasma membrane (cell membrane).

Body regulator

Lipids act as body regulator. They regulate the body functions.

Food

Lipids like butter, oil and ghee are used in cooking (frying etc.)They are used for making the food more delicious.They are used for preparing bakery products.

Industrial use

Lipids are used in the preparation of

Soaps	Lubricants	Cosmetics
Polishes	Paints	Greases

Q.18 What are nucleic acids? What are its types? Discuss its composition?

Ans. **Nucleic acids**

Nucleic acids were discovered by a Swiss physician and biologist,

Johannes Friedrich Miescher.

It can be define as,

"Complex bio-molecules that are made up of repeated units called nucleotides". OR

"Nucleic acids are polynucleotide chains that contain all the information for normal growth and development of a living organism"

- They were first discovered in the nuclei of White blood cells (WBCs) in 1862.
- Later, in 1872, it was also discovered in the sperm head.
- Nucleic acids are present in every living organisms and bordered-line organism like virus.
- Chromosomes present in the nucleus of a cell are made of nucleic acids and proteins.
- Nucleic acids are integral component of genes.
- Gene is a part of chromosome/DNA which is responsible for the transfer of character from parents to offspring.
- The structure of nucleic acids contains all the information for normal growth and development of a living organism.

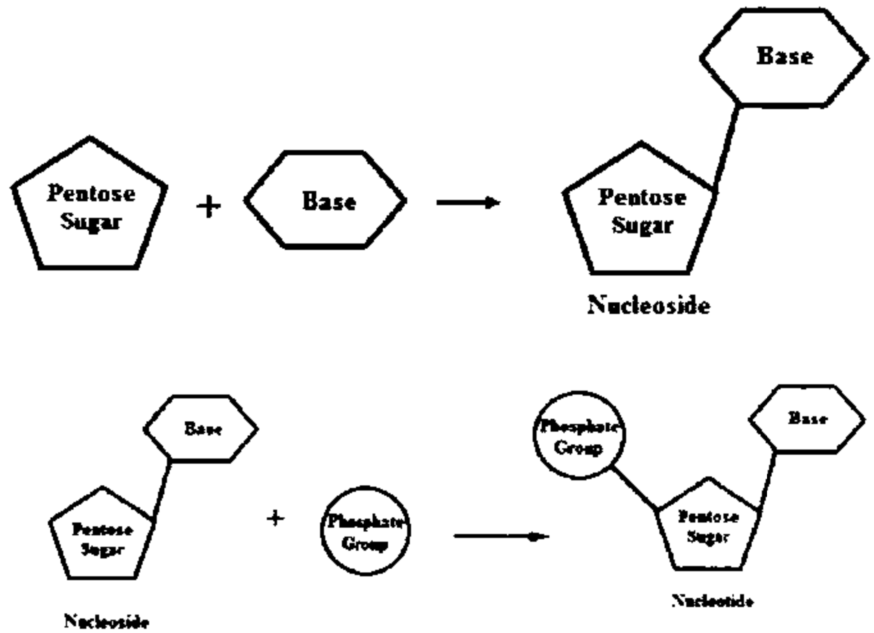
Types of Nucleic Acids

There are two types of nucleic acids i.e.

- Deoxyribonucleic acid (DNA)
- Ribonucleic acid (RNA)

Composition of nucleic acids

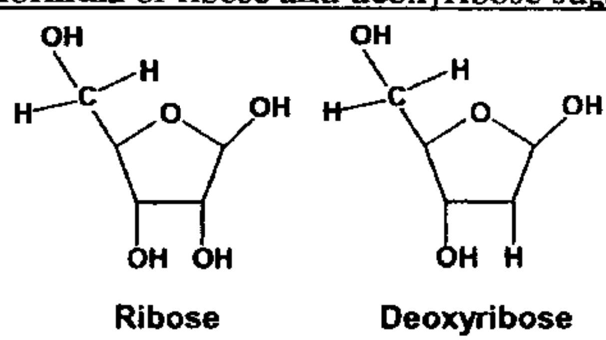
- Nucleic acids are composed of repeated units of nucleotides.
- Nucleotides can be regarded as the building block or monomers of nucleic acids.
- Nucleoside bonded with a phosphate group is called a nucleotide.
- Nucleoside is a nitrogenous base bonded with a pentose sugar like ribose or deoxyribose sugar.



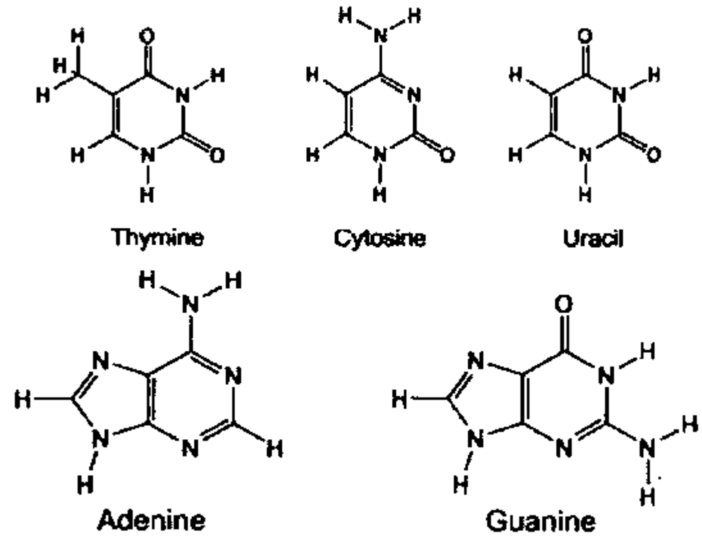
Nucleotides are composed of the following three groups

- Pentose sugar (sugar containing five carbons).That may be ribose sugar in case of RNA and Deoxyribose sugar in case of DNA.
- Nitrogenous bases of five types e.g. adenine, guanine, cytosine, thymine and uracil.(Thymine is present in DNA only. (Uracil is present instead of thymine in RNA).
- Phosphate group

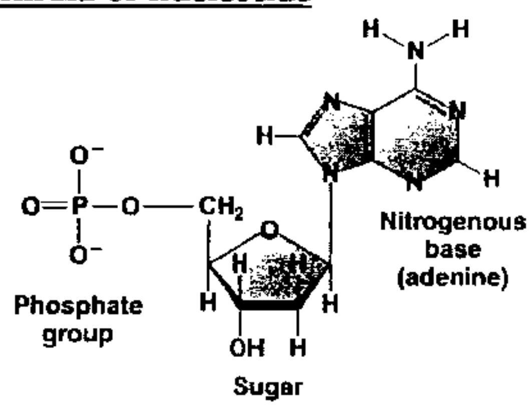
<u>Structural formula of ribose and deoxyribose sugar</u>



Structural formulas of nitrogenous bases



Structural formula of nucleotide



Q.19 Write a detail note on Deoxyribonucleic acid (DNA) and structure of DNA.

Ans. **Definition**

Deoxyribonucleic acid(DNA) is a biological macromolecule that carries hereditary information in many organisms.

OR

Deoxyribonucleic acid (DNA) is a largest macromolecule

that represents the genetic material of an organism.

Explanation

- DNA is present in all living organisms.
- It contains all the information about the normal growth and development of a living organism.
- It contains information about the body structure, eyes colour, hair colour, skin colour etc.
- Therefore, it is also known as "Book of Life."
- It is an integral part of chromosomes present in the nucleus.
- DNA is a polymer of nucleotides.

Composition of DNA

Nucleotide is the monomer of DNA. It is the building block of DNA.Each nucleotide of DNA is composed of the following three groups.

- A pentose sugar (deoxyribose sugar)
- Nitrogenous bases (adenine, guanine, cytosine and thymine)
- A phosphate group

These three groups are covalently bonded with each other to form a nucleotide.

Watson and Crick Model

J.Watson and F. Crick discovered the structure of DNA in 1953. The structure presented by them is known as Watson and Crick Model of DNA.

According to this model,

- There are two chains of polynucleotide, which are twisted around each other in a spiral shape.
- The spiral shape of the two twisted chains of

polynucleotide is called a double helix.

- The pentose sugar and a phosphate group make the backbone of each chain and are present on the outer side of the polynucleotide chain.
- Nitrogenous bases are on the inner side of polynucleotide chains.
- The two strands are held together by hydrogen bonds.
- Adenine of one strand is paired with the thymine of the other strand by two hydrogen bonds.
- Cytosine of one strand is paired with the guanine of the other strand by three hydrogen bonds.
- The order of the nitrogenous base pairs in a strand is code that stores information that is used for protein synthesis.

Q.20 What are the functions of nucleic acids?

Ans. The functions of nucleic acids are described below.

Proteins synthesis

DNA contains the instruction in the form of codes for protein synthesis. RNA receives, read, decodes and uses this genetic information from DNA to synthesize new proteins.

Book of Life

DNA is considered as book of life because it contains all the information about the normal growth and development of a living organism.It contains information about the body structure, eyes colour, hair colour, skin colour etc.

Codes of Information

DNA can store information, reproduce the information, transmit genetic information from parents to offspring. This information is stored in the form of specific codes in DNA.

Q.21 Differentiate between DNA from RNA

Ans. Difference between DNA from RNA

The following table shows the differences between DNA and RNA;

DNA	RNA
Pentose sugar of DNA is deoxyribose.	Pentose sugar of RNA is ribose.
DNA is a double strand of polynucleotide chain.	RNA is a single strand of polynucleotide chain.
DNA has nitrogenous base Thymine. (Other three bases are same)	RNA has nitrogenous base Uracil instead of thymine.
DNA is having no types.	RNA is of three types i.e. mRNA, rRNA, tRNA

Q.22 What are vitamins? Discuss their classification.

Ans. Vitamins

Vitamins are organic compounds that cannot be synthesized by an organism but are very essential in small quantities for the proper functioning of its metabolism and therefore must be obtained through diet.

Explanation

- Vitamins were discovered by a Polish biochemist Casimir Funk.
- He used the word vitamin for the first time in 1912.
- Vitamin is a combination of two words "vital" and "amine."
- The word vital means necessary or essential and the word amine is used for thefunctional group amines ($-NH_2$) because for the first time they were chemically

identified as amines.

- Later on,researchers discovered that not all the vitamins were chemically amine in nature therefore, the last letter "e" was dropped and now the word "vitamin" is used instead of "vitamine"
- A small amount of vitamins is needed for maintaining healthy and proper functioning of the body.
- Vitamins also help in prevention from future problems e.g. Vit-D for bones in old age.
- They play important role in metabolism and immunity of the body.
- They also help in digestion.
- Our body cannot synthesize vitamins and they must be obtained through diet.

Types of Vitamins/ Classification of Vitamins

There are two types of vitamins depending upon its solubility in different solvents.

i. Fats soluble vitamins

ii. Water soluble vitamins

Fats Soluble Vitamins

Those vitamins which are soluble in fats are called fats soluble vitamins.

Examples

- Vitamin A
- Vitamin D
- Vitamin E
- Vitamin K

Water Soluble Vitamins

Those vitamins which are soluble in water are called

water soluble vitamins.

Examples

Examples of water soluble vitamins are

- Vitamin B-Complex
- Vitamin C or Ascorbic Acid

Vitamin B-complex is a complex of eightvitamins that are given below:

- Vitamin B_1also known asthiamine
- Vitamin B_2also known asRiboflavin
- Vitamin B_3also known as niacin
- Vitamin B_5 also known as pantothenic acid
- Vitamin B_6also known as pyridoxine
- Vitamin B_7 also known as biotin
- Vitamin B_9 also known asFolic acid or Folate
- Vitamin B_{12}also known ascyanocobalamin

**Q.23 Vitamins are vital for us, why? OR
Write short notes oneach of the following Vitamins and their importance.**

Vitamin A	**Vitamin B**	**Vitamin C**
Vitamin D	**Vitamin K**	**Vitamin E**

Ans. Vitamins are important for the proper functioning of our body because, they help in remaining healthy and prevention from future problems.Metabolism, digestion and immunity of our body are aided by vitamins.

The importance of some vitamins is given below:

Vitamin A

- Vitamin A is also known as Retinol for its important role in vision.
- It is a fat-soluble vitamin.

- It is needed by the retina of the eye.
- It also keeps the cornea of the eye moist.
- Itis important for growth and development.
- It is also important for the maintenance of the immune system.

Sources

Sources of vitamin A are Milk, butter, eggs, fruits and green vegetables.

Deficiency symptoms

Deficiency of vitamin A causes

- Night blindness
- Burning or irritation of eyes
- Dry skin

Vitamin B

- B vitamins are a class of water-soluble vitamins.
- They play important roles in cell metabolism.
- It is a complex of eight vitamins includingB1, B2, B3, B5, B6, biotin, folic acid and B12.
- It plays important role energy production in cells, nerves, and skin.
- It regulates nerve impulse transmissions.

Sources

Sources of vitamin B-complex are bread, rice, yeast, liver, milk, meat, fish, eggs and green vegetables.

Deficiency symptoms

Deficiency of vitamin-B Complex causes

- Inflammation and irritation of the corners of the mouth.
- Skin diseases

- Tongue or lips inflammation
- Cracks in lips
- Bleeding gums
- Beriberi (by Vit-B1 deficiency, effects cardiovascular system or nervous system)

Vitamin C

- It is also known as ascorbic acid.
- It is used to prevent and treat scurvy.
- It is necessary for the formation of blood and improvement of the immune system.
- It helps in protection against illness including common cold.
- It is an essential nutrient, which is involved in the repair of tissue.
- It is involved in the enzymatic production of certain neurotransmitters.

Sources

Sources of vitamin C are Citrus fruits like oranges, lemons etc, tomatoes, vegetables etc.

Deficiency symptoms

The deficiency of vitamin c causes the following diseases

- Scurvy (a disease of bleeding gums)
- Pain in joints
- Fatigue

Vitamin D

- It is a fat-soluble vitamin.
- It plays important role in increasing intestinal absorption of calcium and magnesium.

- Itregulates the amount of bloodcalcium.
- It is essential for strong bones and teeth.

Sources

Sources of vitamin D are milk, butter, eggs, fish oil and vegetables.

Deficiency

Deficiency of Vitamin D causes

- Rickets (disease of bones)
- Osteomalacia (a disease of bones)
- Impaired Wound Healing
- Bone Loss
- Muscle Pain

Vitamin E

- It is a fat-soluble vitamin.
- It is important for reproduction and helps in fertility.
- It is important for youth preserving.
- It is a defender against the carcinogenic (cancer-causing) effects of certain chemicals.
- It is important for the health of blood and brain
- It has antioxidant properties and thus prevents aging.

Sources

Sources of vitamin E are Bread, rice, eggs, liver, butter, corn and soybean oil.

Deficiency

Deficiency of vitamin E causes

- Premature aging
- Varicose veins
- Skin problems like acne.

- Haemolysis of red blood cells (anemia)
- Sterility
- Visionproblems
- Muscle weakness

Vitamin K

- It is a fat-soluble vitamin.
- It helps in the production of prothrombin (a protein that helps in blood clotting)
- It plays a key role in metabolism and regulating blood calcium levels.

Sources

Sources of vitamin E are fresh green vegetables, liver, egg yolk, meat, cheese etc.

Deficiency symptoms

Deficiency symptoms are:

- Hemorrhage
- Delayed blood clotting
- Excessive bleeding from wounds or surgical sites
- Bleeding from the gastrointestinal tract(GIT)
- Blood in the urine or stool

EXERCISE

A. Choose the correct option.

1. Which one of the following is a disaccharide
   a. Glucose b. Fructose
   c. Sucrose d. Starch
2. A large number of amino acids polymerizes into
   a. Vitamins b. Carbohydrates

c. Protein d. Lipids

3. Glycogen is an example of
   a. Fats b. Nucleic acids
   c. Carbohydrates d. Proteins
4. Deficiency of vitamins A causes
   a. Scurvy b. Rickets
   c. Night blindness d. Aging
5. The compound which is found in every living cell and serves as a centre of information and control is
   a. Protein b. Amino acids
   c. DNA d. Glucose
6. Triglycerides are the building blocks of
   a. Proteins b. Carbohydrates
   c. Lipids Vitamins
7. Sugars are polyhydroxyl derivatives of
   a. Alkyl halides b. Aldehyde
   c. Ketone d. Aldehyde and Ketone
8. Peptide linkage is present in
   a. Carbohydrates b. Lipids
   c. Proteins d. Vitamin
9. Plants convert glucose into
   a. Amino acids b. Lipids
   c. Proteins d. Starch
10. All are present in DNA except
   a. Deoxyribose sugar b. Ribose sugar
   c. Nitrogenous base d. Phosphate unit

ANSWERS:

1	c	2	c	3	c	4	c	5	c

6	c	7	d	8	c	9	d	10	b

B. Write short answers to the following questions.

i. Differentiate between glucose and fructose.

Ans. Difference between glucose and fructose

Glucose	Fructose
Glucose is an aldose sugar.	Fructose is a ketose sugar.
Glucose is less sweet than fructose.	Fructose is sweeter than glucose.
Glucose needs insulin for its metabolism.	Sucrose does not need insulin for its metabolism and thus diabetes patient can use it.
Glucose is less water soluble than fructose.	Fructose is more water soluble than glucose.
Glucose does not turn into fats.	Fructose turns into fats.
It is found in pasta, bread, legumes and vegetables.	It is found in honey, fruits and vegetables.

ii. Write down four uses of lipids.

Ans. See Question 17

iii. How would you differentiate between simple and complex lipids?

Ans. See Question 12

iii. What is meant by denaturing of protein?

Ans. Denaturation of proteins

- When a solution of a protein is boiled, the protein frequently becomes insoluble and the proteins is said to be denatured.
- Denaturationis the disruption and destruction of the structure of protein.
- The denatured protein has the same primary structure

as the original protein but the tertiary structure of the protein is lost.

- Denaturation occurs because the bonding interactions responsible for the secondary structure and tertiary structure are disrupted.
- The most common observation in the denaturation process is the coagulation of the protein.
- A denatured protein is unable to perform its function properly.
- Some time a proteins can be re-natured by a process called re-naturation.

Example:

One of the methods for proteins denaturing is heat. Heat can be used for disrupting hydrogen bonds of proteins.

The denaturation of the proteins in boiling of eggis an example of denaturation. As a result, the proteins in eggs coagulate and is said to be denatured.

v. How would you classify vitamins?

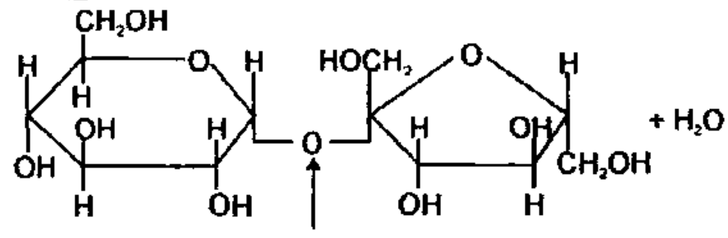
Ans. See Question 22 Topic: Classification of vitamins

vi. Vitamins are vital for us, why?

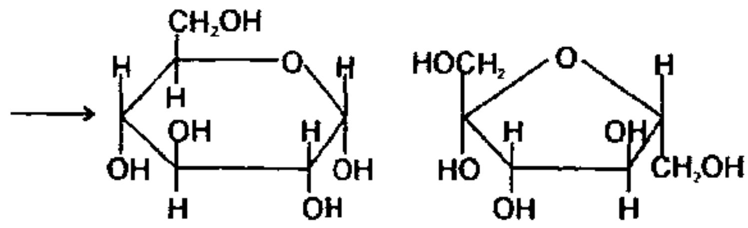
Ans. See Question 23

vii. Write down the products of sucrose hydrolysis.

Ans. Sucrose $\xrightarrow{\text{water}}$ Glucose + Fructose



Sucrose



viii. Draw the general formula of amino acid. Identify the different parts and functional groups present in it.

Ans. See Question 8

ix. Briefly describe the sources and deficiency symptoms of vitamin A.

Ans. See Question 23 (Topic: Vitamin A)

x. Identify the different sources of proteins? Also, list the four uses of proteins.

Ans. See Question 9 and 10

C. Write detailed answers to the following questions.

Q.1 What functions do carbohydrates perform in living organisms.

Ans. Functions of carbohydrates in the living organisms

The main functions of carbohydrates in the living organisms are described below.

Source of energy

- One of the primary functions of carbohydrates is to

provide energy to the body of a living organism.

- They are considered to be the instant source of energy
- Different activities occurring in our body require energy. This energy is obtained from carbohydrates.
- Cells of living organisms convert carbohydrates into the fuel molecule ATP through a process called cellular respiration.

Regulating Blood Glucose

- Maintaining a particular amount of glucose is necessary in our blood for proper functioning of all the organs of our body.
- Excess of glucose in our body is present in the form of glycogen, which is a polysaccharide carbohydrate.
- Whenever we run short of glucose, the glycogen is converted to simple sugar again and the blood glucose level is retained.
- Hence carbohydrates help in regulating blood glucose.

Preventing Protein from use

- Maintaining a regular intake of carbohydrates will prevent protein from being used as an energy source.
- Thus,amino acids will be freed for the syntheses of enzymes, antibodies, and other important proteins.

Preserving Muscles

- Consuming some carbohydrates preserves the muscles.
- During periods of starvation, the body can convert amino acids from muscle into glucose to provide the brain with energy.
- Thus, carbohydrates help muscles from being lost.

Helps in digestion

- Fiber is a type of carbohydrate.

- Fibers promote good digestive health by reducing constipation.
- Fibers lower the risk of digestive tract diseases.

Q.2a. Distinguish between monosaccharides, disaccharides and polysaccharides and also give examples of each one.

Ans. See Question 3

b. How are carbohydrates important to living organisms?

Ans. See Question 1 of exercise long questions.

Q.3. a. How are proteins important to living organisms?

Ans. See Question 10

b. Describe the nature of bonding in protein.

Ans. <u>Nature of Bonding in Proteins</u>

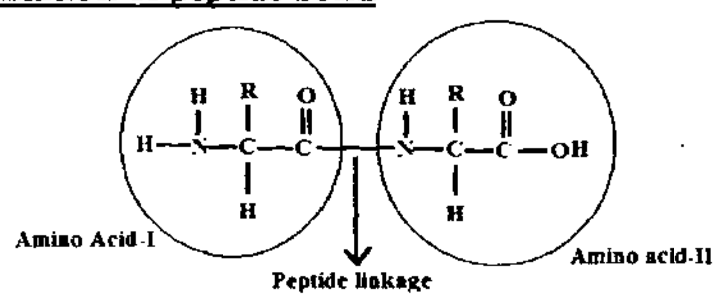
There are three types of bonding in protein molecules:

- Peptide bonding
- Hydrogen bonding
- Disulphide bridge

<u>Peptide linkage</u>

The linkage between the carbonyl carbon of one amino acid with the nitrogen of amino group, of another amino acid is called peptide linkage or peptide bond.

<u>Representation of peptide bond</u>

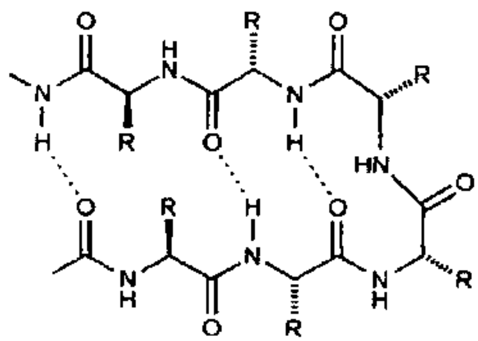


Hydrogen Bonding

The secondary structures of proteins are held together by hydrogen bonds.The hydrogen bonds form as a result of attraction between the oxygen atom of one amino acid and the hydrogen atom attached to the nitrogen of other amino acids.

Representation of Hydrogen Bond

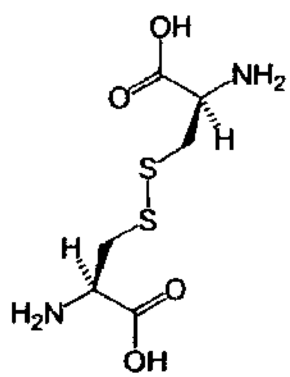
The red lines represent hydrogen bonding in proteins.



Di-sulphide bridge

- A disulphide bond is also known as S-S bond.
- It is a covalent bond derived from two thiol groups (SH).
- Di- sulphide bridge is present in sulphur containing proteins only.

Representation of Di-sulphide bond



Q.4 a. Define the term lipid.

Ans. See Question 11

b. Distinguish between fats and oils.

Ans. See Question 14

c. List four foods that you eat that contain lipids.

Ans. See Question 16

d. How are lipids important to your body?

Ans. See Question 17

Q.5 a.How would you justify DNA as genetic code of life?

Ans. Deoxyribonucleic acid(DNA) is a largest macro-molecule that represents the genetic material of a cell.DNA is identified as the code of life from the as;

- DNA contains the instruction in the form of codes for protein synthesis. RNA receives, read, decodes and uses this genetic information from DNA to synthesize new proteins. Proteins are essential for a cell because they perform different functions. They work as enzymes for catalyzing chemical reactions. They protect and maintain the cell's structure.They help the cells to communicate with each other.
- DNA is present in all living organisms. It contains all the information about the normal growth and development of a living organism. It contains information about the body structure, eye colour, hair colour, skin colour etc. Therefore, it is also known as "Book of Life."
- DNA is an integral part of chromosomes that are present in the nucleus. It can store information, reproduce the information, transmit genetic information from parents to offspring. This information is stored in the form of specific codes in DNA.

b. Distinguish between DNA and RNA.

Ans. See Question 21

c. Explain the function of DNA.

Ans. See Question 20

Q.6 a. Define the term vitamins andclassify it.

Ans. See Question 22

b. Explain the important sources of vitamins.

Ans. Sources of vitamin A are Milk, butter, eggs, fruits and green vegetables.

Sources of vitamin B-complex are bread, rice, yeast, liver, milk, meat, fish, eggs and green vegetables.

Sources of vitamin C are Citrus fruits like oranges, lemons etc, tomatoes, vegetablesetc.

Sources of vitamin D are milk, butter, eggs, fish oil and vegetables

Sources of vitamin E are Bread, rice, eggs, liver, butter, corn and soya-bean oil.

Sources of vitamin E are fresh green vegetables, liver, egg yolk, meat, cheese etc

c. Write down the names of five vitamins and their importance.

Ans. See Question 23

Unit 14

Environmental Chemistry I (Atmosphere)

Q.1 Define Environmental Chemistry. What are the four natural system/spheres of the earth?

Ans. Environmental Chemistry

Environmental chemistry can be define as,

The branch of chemistry, which deals with the study of environment and the changes occurring in it, is called environmental chemistry. OR

The study of the geosphere, hydrosphere, atmosphere, and biosphere of the universe and their importance and changes occurring in them is called environmental chemistry.

Four Systems/Spheres of the Universe

Our universe is comprise of the following four spheres,

Geosphere:

Itrefers to the part of the planet that is solid (also called lithosphere).

Hydrosphere:

It refers to the part of the planet that is water.

Atmosphere:

It refers to gaseous part of the planet.

Biosphere:

It refers to the living part of the planet.

Q.2 Define Atmosphere and discuss the main featuresof atmosphere.

Ans. Atmosphere

Definition

The thick protective blanket of gases around the earth that helps to sustain life is called atmosphere.

Main features of atmosphere

The main features of atmosphere are described below.

Thickness

The thickness of the atmosphere is about 500 km from earth's surface.

Density of atmosphere

The density of atmosphere is $0.0013 g/cm^3$.The density of atmosphere decreases with altitude.

Pressure of atmosphere

The pressure of atmosphere at sea level is 1 atm, but itdecreases with altitude.

Temperature

Temperature of the atmosphere is not constant. The temperature of the atmosphere ranges from -92 ^0C to 1200^0C depending upon the layers of atmosphere.

Mass of atmosphere

The mass of atmosphere is approximately 4.5×10^{15} to 5×10^{15} metric tonnes.

Layers of atmosphere

Atmosphere can be classified in four layers i.e.

- Troposphere
- Stratosphere

- Mesosphere
- Thermosphere

Q.3 Describe the composition of atmosphere.

Ans. Composition of atmosphere

- The composition of atmosphere is not constant; it changes with time and place.
- It is a mixture of gases, water vapours and dust particles.
- The two major gases of the atmosphere are Nitrogen and oxygen.
- The percentage of nitrogen and oxygen collectively is 99% and they are known as main gases.
- The percentage of nitrogen is about 78% and that of oxygen is about 21%.
- Other gases like argon, carbon dioxide, hydrogen, neon, helium etc, occupy the remaining 1% of the total volume and they are known as secondary gases.

The following table shows the types of gases and their percentage.

Gases	Percentage (%)
Nitrogen	78.1
Oxygen	20.9
Argon	0.9
Carbon dioxide	0.03
Hydrogen	0.01
Neon	0.0018
Helium	0.0005

Ozone	0.00006
Water vapours	0.0 to 4%

Q.4 What do you mean by layers of atmosphere? Describe 1st two layers in detail.

Ans. The earth's atmosphere is about 500km thick. It is not uniform across its thickness.

On the bases of this variability at various points in the atmosphere, it has been divided into four layers which are known as layers of atmosphere.These four layers are:

- Troposphere
- Stratosphere/ozonosphere
- Mesosphere
- Thermosphere/ionosphere

The first two spheres are described below:

Troposphere

The layer of the atmosphere, which is closest to the earth surface, is called troposphere.

The word "tropo" means variable, as the conditions of this layer are changing continuously therefore this layer is named troposphere.

Characteristics of Troposphere

The major characteristics of this layer are given below.

Height

The average height of this layer is about 11 km from earth's surface.

However, it is not a constant value rather it changes with latitude, seasons and pressure.

Major particles

Dust particles and water vapours are the constituent of this layer.

Weather phenomenon

The entire weather phenomenon like clouds, winds, rainfalls etc. take place in troposphere.

Major Gases

The major gases of this layer are N_2, O_2, CO_2 and H_2O vapours.

70 to 75% of the atmospheric gases are present in this layer.

Convection of heat

Wind movement is facilitated in this layer due to the convection of heat.

Pressure and density

The pressure and density of the atmosphere decrease with altitude in troposphere.

Lapse rate

In troposphere, the lapse rate is negative. Lapse rate is the change in temperature of the atmosphere with the increase in altitude (height). The decrease in temperature with altitude is called negative lapse rate and vice versa. The temperature decreases at a rate of 6.5^0C per kilometer increase in altitude.

Temperature range

The average temperature near the earth surface is 15°C and −56°C at top of this layer.

Tropopause

It is the area above troposphere. In tropopause the

temperature is constant, and no change occurs in temperature with altitude.

Stratosphere/Ozonosphere

The second layer of atmosphere above the troposphere is called stratosphere.

The word "strato" means spread out. This layer is also called ozonosphere as it contains Ozone(O_3).

Characteristics

The characteristics of stratosphere are described below.

Height

The thickness of this layer is 39 km i.e., it starts at a height of 11km and ends at a height of 50 km above the sea level.

Major component

Ozone is the major component of this layer therefore this layer is also called ozonosphere.

The concentration of ozone increases with altitude. Maximum concentration of ozone is at 30km.

Weather balloons and aircrafts

As the air in this layer is thinner, therefore the weather balloons and aircrafts fly in this region. The thinner air increases the fuel efficiency of the aircrafts due to less resistance.

Ozone formation

Ozone formation occurs in this layer. When oxygen molecule (O_2) absorbs the ultraviolet (UV) radiations from the sun, it decomposes to atomic oxygen (O^*). As atomic oxygen is highly reactive specie, it immediately reacts with another nearby oxygen molecule and ozone is formed. The reaction is given below.

$$O_{2(g)} \xrightarrow{\text{UV light}} O^*_{(g)} + O^*_{(g)}$$

$$O^*_{(g)} + O_{2(g)} \longrightarrow O_{3(g)}$$

Advantage of Ozone

Ozone absorbs and stops the highly energetic ultraviolet (UV) radiations from the sunto reach the earth surface, which can cause skin cancer in human beings and damage to plants.

Ozone depletion

The breakdown of the ozone molecule into monoatomic oxygen and diatomic oxygen by the action of Ultraviolet (UV) radiations and Chlorofluorocarbons (CFC_S) is called ozone layer depletion. Ozone depletion causes a decrease in the concentration of ozone and it has a negative impact on the living organisms.

$$O_{3(g)} \xrightarrow{\text{UV and CFCs}} O^*_{(g)} + O_{2(g)}$$

Temperature range

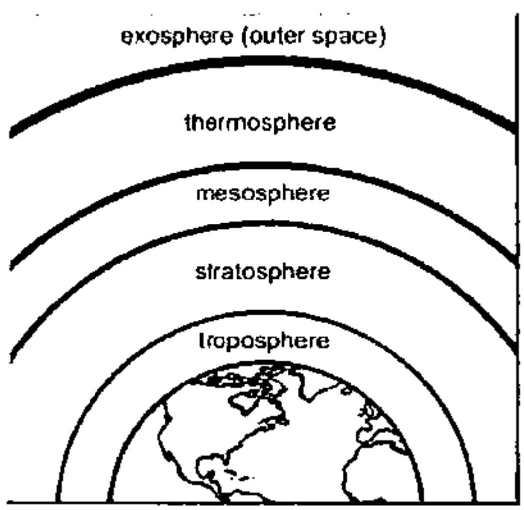
The temperature ranges from -56^0C to -2^0C.

Lapse Rate

In the stratosphere, the lapse rate is positive. Lapse rate is the change in temperature of the atmosphere with the increase in altitude (height). The increase in temperature with altitude is called positive lapse rate and vice versa.The increase in temperature is due to the presence of ozone which absorbs UV radiations from the sun.

Stratopause

The part of the atmosphere, which is above stratosphere is called stratopause. In stratopause the temperature is uniform. Neither increase nor decrease in temperature occurs in stratopause.



Q.5 Discuss the importance of atmosphere.

Ans. Importance of atmosphere

Atmosphere plays a crucial role in the sustainability of life. It is important for all living organisms due to the following reasons.

Protecting shield

It acts as protecting shield around the earth and protects all living organisms from the harmful Cosmic rays, Ultra-violet (UV) rays and other harmful rays of the sun by absorbing them.

Source of gases

- It provides oxygen to all living organisms, which is used in respiration.
- It provides carbon dioxide to plants, which is used in photosynthesis by the plants.
- It provides nitrogen, which is a macronutrient for the plants and important component of protein molecule.

Heat Balance

- Due to atmosphere the temperature of the earth is

suitable for living beings.

- It acts as thermal regulator by preventing the earth from excessive heating or cooling andmaintains an average temperature of $\pm 15^0C$.

Provides Medium

- It provides medium for sound waves to travel so we can hear each other.
- It provides a medium for recycling carbon, nitrogen, oxygen, phosphorous and sulphur etc.
- It provides a medium for radio communications like old wireless radiosT.V signals.
- It provides a medium for aircrafts traveling.

Allows visible radiations

It allows visible radiations from the sun to reach the earth. Due to visible radiation, we can see.

Hydrological cycle

It acts as a carrier for water vapours in hydrological cycle (water cycle).

Medium for energy flow

It helps in flow of energy.

Q.6 Define Pollution and Pollutants.

Also, define air pollution and describe its major pollutants.

Ans. Pollution

The introduction of any substance or any form of energy to the environment, which badly affects the environment and causes damage to humans, plants and animals is called pollution.

Pollutants

- Those substances, which causepollution, are called pollutants.
- Pollutants may be air pollutants, water pollutants and soil pollutants.
- Pollutants that cause air pollution are called air pollutants.
- Pollutants that cause water pollution are called water pollutants.
- Pollutants that cause soil pollution are called soil pollutants.

Air Pollution

According to WHO, Air pollution may be defined as

"the substances released to air either by human activities or by natural activities, in sufficient concentration to cause harmful effects to human beings, vegetation (plants) and other living things".

OR

"Air Pollution is the introduction of harmful substances to air by human activities or natural activities that effect plants, animals and other living organisms".

Major Air Pollutants

Those substances, which cause air pollution, are termed as air pollutants.

Classification of Air Pollutants on the bases of their Origin

Air pollutants are classified into two types on the bases of their origin.

i. Primary Pollutants

Those pollutants, which are added directly to the air

from their source of production, are called primary pollutants.

For example, the addition of carbon monoxide and carbon dioxide from the internal combustion engine of vehicles to the air are primary pollutants.

Major primary pollutants are:

- Oxides of carbon (CO_x)
- Oxides of sulphur (SO_x)
- Oxides of nitrogen (NO_x)

ii. **Secondary Pollutants**

Those pollutants, which are not added directly to the air but are formed from the reaction and interaction of primary pollutants with each other or with other substances, are called secondary pollutants.

For example, acid rainis a secondary pollutant that is formed from the reaction of any of the primary pollutants like SOx/CO_x/ $NO_x$with rain water.

Major secondary pollutants are:

- Acid rain
- Ground level ozone

Classification of Air Pollutants on the bases of state of matter

Air pollutants may be classified into two types on the bases of state of matter i.e.

i. Particulate Pollutants

ii. Gaseous Pollutants

i. **Particulate Pollutants**

Those pollutants, which are solid or liquid particles in nature are called particulate pollutants e.g.dust particles, salt particles and sulphuric acid droplets.

ii. **Gaseous pollutants**

Those pollutants, which are in gaseous state, are called gaseous pollutants.

For example,

- Oxides of Sulphur (SO_x)
- Oxides of Carbon (CO_x)
- Oxides of nitrogen (NO_x)
- Volatile organic compounds(VOCs)

Q.7 Explain and classify the sources of air pollutants.

Ans. Sources of air pollutants

The two main sources of air pollutants are:

- Natural Sources
- Anthropogenic sources or Man-made sources

These two sources are described below in detail.

Natural Sources

The natural sources of air pollutants may include rotten leaves, volcanic eruption, ashes from forest fire etc. The natural sources of air pollutants may be either of Particulate Pollutants or of Gaseous Pollutants.

a. **Natural Sources of Particulate Pollutants**

The contribution of natural sources towards the emission of particulate pollutants is greater than anthropogenic sources.

Natural sources of particulate pollutants include:

- Volcanic eruption
- Soil erosion by wind
- Dust storms
- Natural forest fires
- Salts spray from oceans etc

b. **Natural Sources of Gaseous Pollutants**

Gaseous pollutants are

- oxides of carbon (CO_x)
- oxides of nitrogen (NO_x)
- oxides of sulphur (SO_x)
- volatile organic compound (VOCs)

i. **Oxides of Carbon**

Oxides of carbon may be Carbon monoxide (CO) or Carbon dioxide (CO_2).

a) **Carbon monoxide:**

Natural sources contribute to a lesser extent in the addition of carbon monoxide to air.

Natural sources of carbon monoxides are

- Volcanic eruption
- Decompositionof organic compounds
- Seed germination
- Electrical discharge during storms
- Natural gas emission from volcanic eruption etc.

b) **Carbon dioxide:**

Natural sources of carbon dioxide are given as under:

- Respiration in plants and animals
- Decomposition of organic compounds
- Forest fires
- Emissions from volcanic eruptions

ii. **Oxides of Nitrogen (NO_x)**

Oxides of nitrogen are emitted from bacteria and other microorganisms. Bacteria convert the nitrates (NO_3^-) of soil

into oxides of nitrogen (NO, NO_2)etc.Some bacteria convert atmospheric nitrogen (N_2) into oxides of nitrogen (NO, NO_2)and ammonia (NH_3).

iii. Oxides of Sulphur (SO_x)

A large quantity of sulphur oxides are emitted from volcanoes. Other sources arerock weathering and biological activities etc.

iv. Volatile Organic Compounds

Sources of volatile organic compounds like methane are the following.

- Methane from wetlands
- Methane Animals digestion
- Methane from termite

Anthropogenic Sources / Man-Made sources

Anthropogenic sources also contribute towards the air pollutants. These sourcescontributeto both type of pollutants i.e.

- Particulate Pollutants
- Gaseous Pollutants

A. Anthropogenic sources of Particulate Pollutants

The Man-Made sources of particulates pollutants are:

- Combustion of fuels
- Burning of wood
- Mining
- Mountain blasting etc.

B. Anthropogenic sources of Gaseous Pollutants

Gaseous pollutants are

- Oxides of carbon (CO_x)

- Oxides of nitrogen (NO_x)
- Oxides of sulphur (SO_x)
- Volatile organic compound (VOCs)

i. Oxides of Carbon

Oxides of carbon may be Carbon monoxide (CO) or Carbon dioxide (CO_2).

a) Carbon monoxide

Man-Made sources contribute a lot in the addition of carbon monoxide to air. Automobiles add 75% of this gas to the environment.

Anthropogenic sources of carbon monoxides are

- Incomplete combustion of fossil fuels
- Steel industries
- Automobiles
- Smoking

b) Carbon dioxide

Anthropogenic sources of carbon dioxide are given as under:

- Cooking and baking
- Emissions from industries
- Emissions from automobile
- Thermal power generation

ii. Oxides of Nitrogen (NO_x)

Oxides of nitrogen are emitted from the following sources

- Automobiles and jets
- Industries

- Furnaces
- Thermal power generation

iii. **Oxides of Sulphur (SO_x)**

A large quantity of sulphur oxides are released to the air from burning of fossil fuels such as coal, oil and natural gas. Anthropogenic sources add 32% of the sulphur oxides to the air. Other sources are

- Transportation
- Industries
- Furnaces
- Combustion of Coal

iv. **Volatile Organic Compounds**

Sources of volatile organic compounds like methane etc are added to the air from

- Burning of fossil fuels
- Mining of fossil fuels
- Extraction of fossil fuels
- Exhausts of automobiles

v. **Chlorofluorocarbons (CFCs)**

Chlorine, fluorine and carbon containing compounds are called chlorofluorocarbons (CFCs). They are colourless gases or liquids at room temperature that evaporate easily.They are used as propellant in aerosol (e.g. asthma sprays, deodorant sprays etc.), foams, refrigerators and air-conditioners.

Major sources of CFCs are

- Aerosol sprays
- Refrigerators

- Air conditioners etc.

- CFCs cause ozone depletion by releasing chlorine to the atmosphere.
- Chlorine converts ozone to atomic oxygen and oxygen molecule.
- The reaction is a series of chain reactions and once it is started never stops easily.
- In this reaction,a large amount of ozone is depleted by the chlorine present in CFCs.
- Thus, CFCs are major pollutants that cause ozone depletion.

Q.8 Describe the effects of Air pollutants.

Ans. <u>Effects of Air Pollutants</u>

Different air pollutants have different harmful effects on biotic (living part) and non-biotic (or abiotic i.e. non-living part) components of an ecosystem.

i. <u>Effects of Carbon monoxide</u>

- It is a colourless, odourless, non-irritating and poisonous gas.
- Haemoglobin is an oxygen carrying protein that is present in the blood.Haemoglobinhas more affinity for carbon monoxide than oxygen and binds CO with itself, which badly affects the oxygen carrying capacity of the haemoglobin.This results into blurred vision, headache, nausea,unconsciousness and even death in severe cases, i.e. prolonged exposure to carbon monoxide inhaling.
- Besides this, it can badly affect Central Nervous System and heart.

ii. **Effects of carbon dioxide (CO_x)**

- Carbon dioxide ratio in the atmosphere is regulated by green plants.
- They continuously take excess of the carbon dioxide from the atmosphere.
- If the ratio of carbon dioxide is increased than the permissible limit, it causes Acid rain, global warming and other health problems in human beings.

iii. **Effects of sulphur dioxide (SO_x)**

Adverse effects of sulphur dioxide are.

- Respiratory problems in human beings.
- Increasing rate of corrosion of metals.
- Irritation of eyes and severe headache.
- Asthma,nose and throat problems.

iv. **Effects of nitrous oxides (NO_x)**

- Oxides of nitrogen form ozone by reacting with oxygen and other pollutants.
- It forms the photochemical smog that makes the air hazy (unclear) for vision.
- Nitrogen oxides affect photosynthetic activities of plants.
- They cause respiratory problem and heart failure in mammals.

v. **Poly-aromatic compounds (PAC) and Poly-aromatic hydrocarbons (PAH)**

Poly-aromatic compound and poly-aromatic hydrocarbons are carcinogenic (cancer causing) in nature and may cause leukaemia(a type of cancer) and other diseases.

vi. **Chlorofluorocarbons CFCs**

When chlorine from CFCs is released to the atmosphere, it reacts with the ozone and converts it to atomic oxygen and oxygen molecule thus results in the depletion of ozone layer. As ozone layer absorbs the highly energetic Ultraviolet (UV) rays, after depletion of ozone, the highly energetic rays can reach the earth and adversely affect the life on earth.

vii. **Particulate Matter**

Particulate matter such as lead halides ($PbCl_2$, $PbBr_2$ etc.)are produced by combustion of gasoline products containing lead, which are toxic and affect mankind and other living organisms.

Q.9 Describe the environmental effects of pollutants.

Ans. Environmental effects of Pollutants

Environmental effects of pollution are described below.

i. **Acid Rain**

- The rain, which has pH less than 5.6, is called acid rain.
- Acid rain causes damage to Plants and animals.
- It damages human skin and hair.
- It also badly affects architecture like monuments and historical places.

ii. **Eutrophication**

Pollutants like nitrates cause eutrophication. Eutrophication is the increase in the production of algae and plants in an aquatic ecosystem and a decrease in the production of fishes in the same system, due to the increase in salt contents of water.

iii. Increase in ground level ozone

- Oxides of nitrogen aid in the formation of ground level ozone.
- Ground level ozone causes respiratory problems like asthma; most often in children.
- It can also damage vegetation.

iv. Greenhouse Effect (GHE)

- Gaseous pollutants like Carbon dioxide and methane etc cause greenhouse effect.
- The trapping of sunrays by the greenhouse gases is called greenhouse effect i.e. once the sunrays reach the earthsurface the greenhouse gasses do not let the sunrays escape back.
- Greenhouse gases include COx, NOx and SOx etc.
- Due to greenhouse effect, the average temperature of the universe is increasing continuously which is termed as Global Warming.

v. Global Warming

- The average temperature of the universe is increasing continuously; this phenomenon is termed as global warming.
- Melting of polar ice caps, irregular changes in weather and rise in sea level is due to global warming. Most of the islands have been drowned due to global warming.

vi. Ozone depletion (holes in ozone layer)

- Ozone depletionoccurs due to the pollutants like CFCs.
- Due to the presence of such pollutants the concentration of ozone in the stratosphere is

decreasing day by day.

- The depletion in ozone layer allows the highly energetic rays to reach the earth causing skin cancer and other adverse effects on living organisms.

Q.10 Define acid rain. How does it formed?

Ans. Acid Rain

- Rainwater is slightly acidic in nature having pH of 5.6 to 6.0 due to the presence of carbonic acid (H_2CO_3) in rainwater.
- Carbonic acid is formed when atmospheric carbon dioxide reacts with rainwater.
- Sometimes the pH of rainwater drops below 5.6, which is then termed as acid rain.
- Thus, we can say that, Rain with a pH less than 5.6 is called acid rain.
- Rain with a pH of 2.1 has also been recorded.
- Acid rain is formed due to the presence of oxides of carbon, nitrogen and sulphur in atmosphere.
- These oxides react with rainwater forming Carbonic acid(H_2CO_3), nitric acid (HNO_3) and sulphuric acid (H_2SO_4).
- The presence of these acids makes the rain acidic.

Formation of acid rain / Causes of acid rain

Our atmosphere contains a huge amount of oxides of sulphur (SOx), Oxides of nitrogen (NOx) and Oxides of carbon (COx) as pollutants. These oxides are emitted from various natural activities and anthropogenic activities such as volcanic eruption, burning of fossil fuels, automobiles, industries etc.

i. **Acid rain due to Carbon dioxide**

Carbon dioxide reacts with rainwater to form carbonic acid.The presence of carbonic acid makes the rainwater acidic and causes acid rain.

The reaction is given as under.

$$CO_{2(g)} + H_2O_{(l)} \longrightarrow H_2CO_{3(aq)}$$

ii. **Acid rain due to oxides of sulphur (SOx)**

Oxides of sulphur react with rainwater and produce sulphuric acid (H_2SO_4).The presence of sulphuric acid makes the rainwater acidic and causes acid rain.

The reaction is completed in the following steps.

a) **Formation of Sulphur trioxide:**

In the first step, sulphur dioxide (SO_2) is oxidized to sulphur trioxide (SO_3).

$$SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_3$$

b) **Formation of sulphuric acid:**

The SO_3formed in the first step is very reactive and is soluble in water, resulting in the production of sulphuric acid, which makes the rainwater acidic.

$$SO_{3(g)} + H_2O_{(l)} \rightleftharpoons H_2SO_{4(aq)}$$

iii. **Acid rain due to oxides of Nitrogen (NOx)**

Oxides of nitrogen react with rainwater to form nitric acid.The presence of nitric acid makes the rainwater acidic and causes acid rain.

The reactions are given as under.

a) **Oxidation of NO to NO_2:**

Nitric oxide is oxidized to nitrogen dioxide, by reacting with ozone

$$NO_{(g)} + O_{3(g)} \xrightarrow{h\gamma} NO_{2(g)} + O_{2(g)}$$

b) **Oxidation of NO_2 to NO_3:**

Nitrogen dioxide is oxidized to nitrogen trioxide, by reacting with more ozone.

$$NO_{2(g)} + O_{3(g)} \longrightarrow NO_{3(g)} + O_{2(g)}$$

c) **Formation of N_2O_5:**

Nitrogen trioxide reacts with nitrogen dioxide to form dinitrogen pentoxide.

$$NO_{3(g)} + NO_{2(g)} \longrightarrow N_2O_{5(g)}$$

d) **Formation of acid rain:**

Dinitrogen pentaoxide reacts with rainwater to form nitric acid.

$$N_2O_{5(g)} + H_2O_{(l)} \longrightarrow 2HNO_{3(aq)}$$

Nitric acid can also be produced when the nitrogen dioxide reacts directly with water.

Nitrous acid (HNO_2) is also produced in this reaction along with nitric acid.

$$2NO_{2(g)} + H_2O_{(l)} \longrightarrow HNO_{3(aq)} + HNO_{2(aq)}$$

Q.11 Describe the effects of acid rain.

Ans. Effects of acid rain

Acid rain has adverse effects on living matters as well as non-living materials.

The effects of acid rain are described below.

i. **Effects of acid rain on fishes and wildlife**

- Acid rain badly affects the aquatic lives, as they are very sensitive towards acidity.
- Acid rain has a pH less than 5.6 and most fishes cannot hatch their eggs at pH 5.
- Adult fishes may die due to low pH.

- Acid rain also destroys the sources of food in an aquatic ecosystem.
- Some fishes and frogs can tolerate low pH but acid rain leads to scarcity of food for them.
- For example, frog sustains its life at pH4 but the "Mayflies" that frogs eat,cannot survive at low pH.

ii. Effects of Acid on Plants and Trees

- Acid rain has devastating effects on plants and trees.
- Plants and trees, particularly the buds and tips of young plants are very sensitive towards acid rain.
- The minerals and nutrients needed by the plants for their growth get flown away by acid rain.

iii. Effect of acid rain on architectures

- Acid rain has catastrophic effects on buildings, sculptures and other solid matters.
- Most of the buildings and sculptures are made up of limestone and marbles.
- Limestone and marbles contain Calcium carbonate ($CaCO_3$).
- $CaCO_3$ reacts with sulphuric acid present in acid rain to form Calcium Sulphate ($CaSO_4$).
- The reaction is given as under,

$$CaCO_{3(s)} + H_2SO_{4\,(l)} \longrightarrow CaSO_{4(aq)} + CO_{2(g)} + H_2O_{(l)}$$

- $CaSO_4$ is soluble in water and is washed away with rainwater which results in the deformation and erosion of the historical statues.
- Historical statues of Greece and Italy, Taj Mahal of India have been eroded by acid rain.

iv. Effects on Human Beings

- Acid rain damages lungs, hair and skin of human beings.
- It gives rise to water borne diseases.
- The heavy metals released from various substances due to the reactive nature of acid rains cause serious health problem, as these heavy metals then reach the water beds.

v. Effects on soil

- Acid rain washes away the mineral and nutrients that are essential for plants growth.
- It increases the acidity of soil due to which plants growth is affected.
- It changes the nature of fertilizers added to the soil for plants growth.

Q.12 What is meant by ozone? Discuss its characteristics / physical properties.

Ans. Ozone

Definition:

Ozone is an allotropic form of oxygen consisting of three chemically bonded oxygen atoms.

Discovery:

In 1840, a scientist Schonbein found that when an electric discharge is passed through air (oxygen), a new gas of strange smell is formed. He called it ozone. The word ozone is derived from Greek word ozoaterr, which means smell. So the name ozone was given to it, due to its irritating smell.

Importance:

Ozone is important in a sense that it absorbs the highly

energetic rays such as UV-rays and prevents it from reaching the earth. These rays have devastating effects on living organisms. Besides this ozone also contributes to greenhouse effect due to which the temperature of the earth is in normal range and life is sustainable on earth.

Molecular formula:

The molecular formula of ozone is O_3.

Molar mass:

Molar mass of ozone is 58 g/mol.

Physical properties / Characteristics of ozone

Colour: Ozone is bluish in colour.

Odour: Ozone is irritating in odour.

Allotrope: It is the allotropic form of oxygen

Solubility: It is soluble in water, turpentine oil, glacial acetic acid and carbon disulphide.

Liquefaction: Ozone liquefies at -112^0C adopting a pale blue colour.

Effects on Rubbers: It causes rubber to harden and produces cracks in tyres.

Occurrence:

It occurs in higher concentration at 30 Km altitude in the stratosphere. Stratosphere is also known as ozonosphere due to the presence of ozone in this layer. The maximum concentration of ozone in stratosphere is 10 PPM (parts per million).

Q.13 Discuss the formation of ozone.

Ans. Formation of ozone

The formation of ozone occurs both naturally and artificially. Both are described below:

a) **Artificial method**

A number of methods are used for the preparation of ozone. One of these methods is the use of ozonizer. The method was discovered for the first time bySchonbein. An ozonizer is an electric discharger. When an electric discharge is passed through air, ozone is formed.

The reaction is given below.

$$3O_{2(g)} \xrightarrow{\text{electric discharge}} 2O_{3(g)}$$

b) **Natural Method**

Formation of ozone occurs in the presence of ultraviolet UV radiations from the sun.

The oxygen present in the atmosphere is converted to ozone by the reaction given below.

$$3O_{2(g)} \xrightarrow{UV} 2O_{3(g)}$$

The above reaction is completed in two steps.

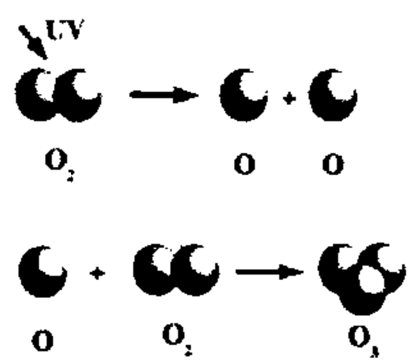
In the first step molecular oxygen is converted to highly reactive atomic oxygen atoms.

$$O_{2(g)} \xrightarrow{UV} 2O^{\bullet}$$

In the second step the highly reactive species of atomic oxygen formed in the first step, reacts with the molecular oxygen and formation of ozone occurs.

$$O_{2(g)} + O^{\bullet} \xrightarrow{UV} O_{3(g)}$$

Diagram



Q.14 What is meant by ozone layer depletion? How ozone layer is depleted?

Ans. **Ozone layer depletion**

The breakdown of the ozone molecule into monoatomic oxygen and diatomic oxygen by the action of Ultraviolet (UV) radiations and Chlorofluoro-carbons (CFC_S) is called ozone layer depletion.

OR

The decrease in the concentration of ozone in the stratosphere below its permissible level is termed as ozone depletion

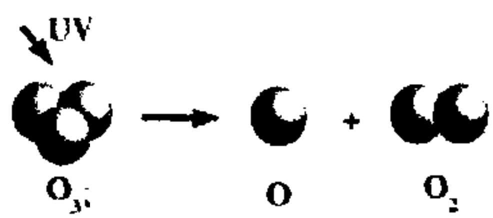
Chemical Reaction

The chemical reaction for ozone depletion is given below,

$$O_{3(g)} \xrightarrow{\text{UV and CFCs}} O^*_{(g)} + O_{2(g)}$$

Ozone depletion causes a decrease in the concentration of ozone in the stratosphere and it has a negative impact on the living organisms because it protects them from the harmful UV radiations of the sun.

Diagram:



Causes of Ozone depletion

- Several pollutants are responsible for the depletion of ozone layer.
- Among these pollutants, chlorofluorocarbons CFCs contribute 80% to the depletion of ozone.
- Other pollutants depleting ozone layer are hydro-

chlorofluorocarbons (HCFCs) and Volatile organic compounds (VOCs).

- These substances are added to the atmosphere from automobiles, industries, aerosols and refrigerants.
- These compounds once reach the stratosphere; the UV radiations convert their molecular state to highly reactive atomic state (radicals).
- For gaining stability these highly reactive species (radicals) react with ozone of the stratosphere and impart its radical character to the specie formed as a result of this reaction.
- The reaction continues till the stabilization of all radicals.

i. <u>Ozone depletion due to CFCs</u>

Chlorofluorocarbons are used in aerosol sprays, refrigerators and air conditioners. The chlorofluorocarbons when get released to the stratosphere, theyget decomposeddue to radiations and produce highly reactive atomic chlorine i.e. chlorine radical.

The chlorine radicals formed then react with ozone and convert it to other species which results a decrease in the concentration of ozone.

<u>Chemical Reactions</u>

$$CFCl_3 \xrightarrow{\text{UV light}} \underbrace{CFCl_2 + Cl^\bullet}_{\text{Radicals}}$$

The atomic chlorine (radical) produced in the first step reacts with ozone and convert it to oxygen (O_2).

$$Cl^\bullet + O_{3(g)} \longrightarrow ClO + O_{2(g)}$$

$$ClO + O^\bullet \longrightarrow Cl^\bullet + O_{2(g)}$$

The free radical chlorine atom is then free to attack another ozone molecule

$$Cl^{\bullet} + O_{3(g)} \longrightarrow ClO + O_{2(g)}$$

$$ClO + O^{\bullet} \longrightarrow Cl^{\bullet} + O_{2(g)}$$

Again, another free radical chlorine atom is produced which attacks another ozone molecule.These two reactions occur again and again resulting in ozone depletion.

ii. Ozone layer depletion due to NOx

Oxides of nitrogen such as nitric oxide (NO), nitrous oxide (N_2O) and Nitrogen dioxide (NO_2) are converted to radicals by the action of UV radiations. These highly reactive radicals react with ozone and cause a decrease in concentration of ozone.

Chemical reaction

$$NO \xrightarrow{hv} NO^{\bullet}$$

$$NO^{\bullet} + O_{3(g)} \longrightarrow NO_{2(g)} + O_{2(g)}$$

iii. Ozone layer depletion due to Atomic Oxygen

Atomic oxygen is also called nascent oxygen. It is produced when molecular oxygen of the atmosphere is converted to atomic oxygen in the presence of UV light.

Atomic oxygen contributes 18% to the depletion of ozone layer.

Chemical Reaction

In the first step, molecular oxygen is decomposed to atomic oxygen.

$$O_2 \xrightarrow{hv} O^{\bullet} + O^{\bullet}$$

The atomic oxygen produced reacts with ozone and convert it to oxygen (O_2), resulting in a decrease in concentration of ozone.

$$O_{3(g)} + O^{\bullet} \longrightarrow 2O_{2(g)}$$

iv. **Ozone layer depletion due to SOx**

An oxide of sulphur such as sulphur dioxide is converted to sulphur dioxide radical in the presence if UV light. The sulphur dioxide produced in the first step reacts with ozone and converts it to oxygen (O_2) resulting a decrease in its concentration.

Chemical reactions

$$SO_{2(g)} \xrightarrow{hv} SO_2^{\bullet}$$

$$SO_2^{\bullet} + O_{3(g)} \xrightarrow{hv} SO_{3(g)} + O_{2(g)}$$

Q.15 Describe the effects of ozone layer depletion.

Ans. **Effects of ozone depletion**

Ozone layer absorbs the UV-rays of the sun and protects us from these highly energetic rays.The depletion in ozone layer is referred as hole in ozone in common language.This hole in ozone allows the highly energetic rays to reach the earth surface, thus affecting the life on earth.The adverse effects of ozone depletionare described below.

Skin Cancer

UV rays cause skin diseases like sunburn and skin cancer.It damages the skin tissues.

Cataract eyes

Exposure to UV-rays causes eyes problems including cataract disease of the eyes.

Immune system

Exposure to UV rays weakens the immune system and its impairment.

Aging

UV rays accelerate aging of skin, as a result a person

looks older than his actual age.

Amphibians

It badly affects the ratio of amphibians in every stage of their life, resulting a decrease in their population.

Marine life

UV rays have high penetrating power. It penetrates into the marine ecosystem and kills various microorganisms and phytoplankton.

Plants

UV rays alter the time of flowering in some plants. It affects their growth and development.

Animals

It causes serious problems for both humans and animals.

Materials

It reduces the life span of certain materials like nylon, plastic etc.

Q.16 How can we control ozone depletion?

Ans. **Ways to overcome ozone depletion**

Ozone depletion is a problem at a global level. Every individual can play a pivotal role in bringing down the ozone layer depletion issue. We can control the,.ozone layer depletion in the following ways.

- Using recycled productsin order to reduce the use of excess energy from fuels.
- Buying air-conditions and refrigerators that do not use HCFCs as refrigerants.
- Buying aerosol products that do not use HCFCs or CFCs as propellants.

- Minimizing refrigerant leakage by regular inspection and maintenance.
- Buying and using recycled products.
- Using public transport so that less ozone depleting gases are released to atmosphere.
- Avoid using personal cars.
- Saving energy.

Q.17 Define Global Warming. Discuss the effects of global warming.

Ans. Global Warming

"The increase in average temperature of the earth's surface (land and water) and its atmosphere is called global warming".

Global warming is due to greenhouse effect.

Greenhouse effect

- Our planet is surrounded by a blanket of gases like a greenhouse.
- These gases are known as greenhouse gases.
- Greenhouse gases are CO_2, CH_4, NO_2, O_3 etc.
- These gases are produced by certain natural and anthropogenic activities.
- These activities may be deforestation, burning of fossil fuels, automobiles, industries etc
- When the radiations from the sun are reflected back from the earth, they are absorbed by the greenhouse gases resulting into an increase in temperature of the earth's surface.
- This increase in temperature of the earth surface is termed as Global warming.

- Researchers have showed that average temperature of the planet has increased over the last few decades. This is due to the industrial revolution and mechanized form of living throughout the world. Every day tonnes of gaseous pollutants are being added to the atmosphere, which act as greenhouse gases resulting into global warming.

Effects of Global Warming

The effects of global warming can be studied under the following categories.

- **Desertification**

Global warming has changed the rain pattern of certain areas and has converted them to deserts.

- **Melting of polar ice caps**

Polar ice caps of the planet are melting day by day due to increase in temperature, resulting an increase in floods.

- **Rise in Sea level**

Increase in temperature causes thermal expansion of ocean water. Besides this due to melting of ice and snow, the sea level rises which has drowned several islands.

- **Stronger storms and cyclones**

The surface temperature of the seawater is increasing due to global warming resulting into strong storms and cyclones.

EXERCISE

A. Choose the correct option.

1. Ozone is present in
   a. Mesosphere b. Thermosphere
   c. Stratosphere d. Troposphere
2. All are air pollutants except,
   a. NO_2 b. N_2
   c. SO_2 d. SO_3
3. Which one of the following is responsible for global warming
   a. Increase in concentration of N_2
   b. Increase in concentration of CO_2
   c. Increase in concentration of O_2
   d. Increase in concentration of O_3
4. The pH of acid rain is less than
   a. 13.6 b. 10.6
   c. 7.6 d.5.6
5. The coldest region in the atmosphere is
   a. Troposphere b. Stratosphere
   c. Mesosphere d. Thermosphere
6. Ozone is formed in the presence of ultraviolet radiations from,
   a. O and O b. $O_2$and O
   c. $O_2$and O_2 d. $O_2$and O_3
7. The gas(es) which is/are responsible for acid rainis/are
   a. SO_2 b. NO_2
   c. CO_2 d. All SO_2, $NO_2$and CO_2

8. On the basis of temperature variation, the number of atmospheric regions are

a. Five b. Two

c. Three d. Four

9. The gas which protects the earth surface from ultraviolet radiations is

a. CO_2 b. N_2

c. O_3 d. O_2

10. Lowest temperature in troposphere is,

a. 5°C b. –5°C

c. 56°C d. –56°C

ANSWERS:

1	c	2	b	3	b	4	d	5	c
6	b	7	d	8	d	9	c	10	d

B. Write short answers to the following questions.

i. How ozone layer is depleted in the atmosphere?

Ans. See Question 14

ii. Differentiate between primary and secondary pollutants. Write the names and sources of greenhouse gases to the atmosphere.

Ans. See Question 6 (Topic: Primary pollutants and secondary pollutants)

<u>Names and sources of Greenhouse gases</u>

<u>Carbon dioxide CO_2:</u>

Sources of carbon dioxide are

- forest fires
- volcanic eruptions

- emissions from industries
- emissions from automobile

Oxides of nitrogen (NO_2, N_2O)

Oxides of nitrogen are emitted from the following sources

- automobiles and jets
- industries
- furnaces
- thermal power generation

Oxides of Sulphur (SOx)

- volcanoes
- rock weathering
- transportation
- industries
- furnaces
- combustion of coal

Chlorofluorocarbons (CFCs)

Major sources of CFCs are

- Aerosol sprays
- Refrigerators
- Air conditioners etc

iii. Define environmental chemistry and atmosphere.

Ans. See Question 1 and 2

iv. Sketch and briefly discuss the composition of atmosphere, by mentioning the percentage of each component.

Ans. See Question 3

v. How the acid rain affect the building material or statues?

Ans. See Question 11 Topic: Effect of acid rain on architectures

vi. Increase in concentration of CO_2 causes greenhouse effect, justify it.

Ans. Carbon dioxide, water vapours and clouds contribute about 20%, 50% and 25% to greenhouse effect, respectively. Although the contribution of water vapours to greenhouse effect is greater than that of carbon dioxide but still it has been found that carbon dioxide is the gas that contributes to greenhouseeffect mostly.

This is because the concentration of water vapours in the atmosphere is dependent on the concentration of carbon dioxide. Water vapours can sustain in the atmosphere only at a higher temperature. This higher temperature is provided by the greenhouse heating of Carbon dioxide. Thus, a decrease in concentration of carbon dioxide in the atmosphere decreases the greenhouse heating of atmosphere, which results into an indirect decrease in the concentration of water vapours in the atmosphere.

Onthe other hand, carbon dioxide remains a gas at a wider range of temperatures than water and independently contributes to the greenhouse heating. Thus, increasing concentration of carbon dioxide will definitely increase the greenhouse effect.

vii. Briefly discuss how the acid rain affects the aquatic life?

Ans. See Question 11 (Topic: Effects of acid rain on fishes and wildlife)

viii. List the sources that produce CO and CO_2 to atmosphere.

Ans. Natural Sources

i. Carbon monoxide:

Natural sources of carbon monoxides are

- Volcanic eruption
- Decomposition of organic compounds
- Seed germination
- Electrical discharge during storms
- Natural gas emission from volcanic eruption etc

ii. Carbon dioxide:

Natural sources of carbon dioxide are given as under:

- Respiration in plants and animals
- Decomposition of organic compounds
- Forest fires
- Emissions from volcanic eruptions

Anthropogenic sources

i. Carbon monoxide

Anthropogenic sources of carbon monoxides are

- Incomplete combustion of fossil fuels
- Steel industries
- Automobiles
- Smoking

ii. Carbon dioxide

Anthropogenic sources of carbon dioxide are given as under:

- Cooking and baking

- Emissions from industries
- Emissions from automobile
- Thermal power generation

ix. What are the adverse effects of Global Warming?

Ans. See Question 17 Topic: Effects of global warming

x. What is the importance of ozone?

Ans. Importance of ozone

Ozone is important in a sense that it absorbs the highly energetic rays such as UV-rays and preventsthem from reaching the earth. These rays if reach the earth can cause serious health problems in human beings and other living organisms. Besides this ozone also contributes to greenhouse effect due to which the temperature of the earth is in normal range and life is sustainable on earth.

C. Write detailed answers to the following questions.

Q.1 a) Sketch and identify the different layers of atmosphere.

Ans. See Question 4

b) Differentiate between stratosphere and troposphere.

Ans. **Difference between stratosphere and troposphere:**

Troposphere	Stratosphere
It is the first layer of the atmosphere closest to the earth surface.	It is the second layer of the atmosphere which lies next to troposphere.
The average thickness of this layer is 11km.(0 km to 11km)	The average thickness of this layer is 39km.(11 km to 50 km)
The entire weather phenomenon	Weather phenomenon does not

takes place in this layer.	occur in this layer.
Water vapours, dust particles and clouds are found in this layer	Water vapours, dust particle and clouds are absent in this layer
Temperature lapse rate is negative in this layer.	Temperature lapse rate is positive in this layer.
Atmospheric gases like N_2, O_2, CO_2etc are major components of this layer.	Ozone (O_3) is the major component of this layer.
This layer ends at tropopause.	This layer ends at stratopause.
Temperature range in this layer is 15°C to–56°C	Temperature range in this layer is –56°C to–2°C

Q.2 a) Air is polluted in the big cities of Pakistan, justify the statement.

Ans. Big cities of Pakistan are at greater risk to air pollution. There are a large number of industries in big cities of Pakistan, which are adding a large amount of pollutants to the atmosphere.Fossil fuels like coal, diesel and petroleum are used for running heavy machineries of these industries. Combustion of these fossil fuels produce a large amount of carbon monoxide, carbon dioxide, sulphur dioxide and other air pollutants that make the air polluted.

Beside industries, vehicles including trucks, jeeps, cars, buses etc. are used by people for their daily basic needs of transportation. These automobiles cause immense amount of air pollution. Moreover, mining operations and stone crushers are also contributing to air pollution in big cities.

b) Enlist the main sources of Air Pollution.

Ans. See Question 7

c) Prove that oxides of nitrogen and sulphur cause air pollution.

Ans. Oxides of nitrogen

- Common oxides of nitrogen are nitric oxide (NO) and nitrogen dioxide (NO_2).
- These gases are produced from Automobiles, jets, industries, furnaces and thermal power generation.
- Nitric oxide is highly corrosive gas that can affect our health and environment.
- Oxides of nitrogen react with rainwater in the atmosphere to form nitric acid (HNO_3) which causes acid rain and we know that acid rain is harmful to both living and non-living.
- They form the photochemical smog that makes the air hazy for vision and cause many respiratory diseases.In 1952"the great smog of London" killed about 12,000 people and 100,000 suffered from respiratory ailments.
- Nitrogen oxides also affect the photosynthetic activities of plants.
- Theyalso cause respiratory problem and heart failure in mammals.Long-term exposure to high levels of nitrogen dioxide can cause chronic lung disease.

On the bases of the above adverse effects of oxides of nitrogen, we can say that oxides of nitrogen cause air pollution.

Oxides of Sulphur

Oxides of sulphur mainly include sulphur dioxide (SO_2) and sulphur trioxide (SO_3).These are released to the air by burning fossil fuels such as coal, oil and natural gas. Anthropogenic sources add 32% of the sulphur oxides to the

air. Oxides of sulphur such as sulphur dioxide can cause air pollution because when it reacts with rain water in the atmosphere it forms sulphuric acid, which is the main component of acid rain. Acid rain can cause deforestation. It can acidify water to destroy aquatic life. Moreover, it corrodes building materials and paints.

Health effects of oxides of sulphurinclude:

- Respiratory problems in human beings
- Increasing rate of corrosion of metals
- Irritation of eyes andsevere headache
- Asthma andnose and throat problems

On the bases of the above adverse effects of oxides of sulphur on the atmosphere, we can say that oxides of sulphur cause air pollution.

d) Enlist the effects of air pollution.

Ans. See Question 8 and 9

Q.3 a) What would be the result if rainwater is acidic?

Ans. See Question 11

b) What could be done to minimize the formation of acid rain?

Ans. <u>Ways to minimize the formation acid rain</u>

Acid rain can be minimized by taking the following measures.

<u>Wise use of Transportation</u>

Combustions of fossil fuels in automobiles produce carbon monoxide and carbon dioxide.

These two oxides cause acid rain; therefore, using alternated modes of transportation will decrease the usage of fossil fuels and thus decreasing acid rain. Avoid using personal

car and using public transport will be advantageous, but, as the use of transport is inevitable in modern age the use of environment friendly transport such as hybrid vehicles and electric model vehicles should be considered. Walking by foot to cover short distances is also recommended in order to get rid of pollution of vehicles.

Alternative fuels

Reducing the use of non-renewable resources and using renewable sources like wind energy, solar energy etc., are also helpful in minimizing acid rain.

Energy conservation

Energy conserving is the first step towards controlling acid rain. Energy can be conserved by turning off the electric appliance when not in use, limited use of Air conditions and using recycled products etc.

Public awareness

Awareness of public regarding effects of acid rain and its prevention will be more helpful.

c) Write down the effects of acid rain on human, plants, soil and materials.

Ans. See Question 11

Q.4 a) Explain ozone layer depletion.

Ans. See Question 14

b) Where does ozone layer lie in the atmosphere?

Ans. Ozone layer lies in the stratosphere layer of the atmosphere. Due to the presence of ozone in this layer stratosphere is also called ozonosphere.The concentration of ozone is maximum at an altitude of 30km.

c) What evidence can you find that depletion of ozone occurs in the atmosphere?

Ans. **Evidences for ozone depletion**

The evidences for depletion in ozone layer are given below.

Decrease in concentration

It was discovered by the scientists in 1980s that the ozone layer was decreasing in concentration in the lower region of the stratosphere of the Antarctic region. The decrease in concentration of ozone from its permissible limit is an evidence for ozone depletion.It was observed through NASA's satellite, called Aura satellite. The severely depleted are of ozone layer was termed as ozone hole.

Increase in ratio of skin cancer

Ozone protects us from highly energetic radiations such as UV radiations. UV radiations if reach the earth can cause several skin diseases along with other diseases. As the thinning of ozone layer is most pronounced in the polar regions therefore an increase in ratio of skin diseases such as sun burn, skin cancer and eye cataracts in the Antarctic region has been reported, which is a strong evidence regarding ozone depletion.

d) Recommend few ways to protect the ozone layer.

Ans. See Question 16

Q.5 a) Summarize the components of stratosphere.

Ans. See Question 4 (Topic: Major particles, Major gases)

b) Describe ozone formation.

Ans. See Question 13

c) Greenhouse effect is good or bad for us, explain.

Ans. Greenhouse Effect

Greenhouse Effect has both advantages and disadvantages for living beings on theplanet.

Advantages

The advantages of greenhouse effect are described below.

Optimum Temperature

All living beings require an optimum temperature of 15°Cfor their survival. This optimum temperature is provided by greenhouse effect. In the absence of greenhouse effect life would be not sustainable on the earth because the temperature without greenhouse effect would be −18°C.

Absorption of radiations

Highly energetic rays cannot reach the earth due to the presence of greenhouse gases in the atmosphere. These gases absorb the highly energetic radiations of sunrays and protect us from their adverse effects.

Plants Growth

Greenhouse effect provides a suitable temperature for plants growth. In addition, artificialgreenhouses are also used for growing, out of season crops.

Disadvantages

The negative aspects of greenhouse effect are given below.

Global warming

Global warming is caused by greenhouse effect, but, it is due to the excess of these greenhouse gases. Due to global warming the average temperature of the earth is increasing

gradually.This increase in average temperature has the following adverse effects;

- Desertification
- Melting of polar ice caps
- Rise in Sea level
- Stronger storms and cyclones

The above adverse effects are indirectly produced by greenhouse effect.

Increased level of CO_2

Plantgrowth requires a specific concentration of carbon dioxide in the atmosphere. The increase in concentration of CO_2 from its normal limit disrupts the photosynthesis process of plants.

d) Predict the outcomes of global warming.

Ans. See Question 17 (Topic effects of Global Warming)

Unit 15

Environmental Chemistry II (Water)

Q.1 Write a note on the occurrence and distribution of water.

Ans. Occurrence of Water

- The total amount of water present on the earth is 1.33 billion cubic kilometres.
- Approximately 97.5% of water is present in the form of oceans, which is not suitable for drinking purpose.
- The remaining 3% is present in the form of glaciers, ice caps, underground water etc.
- Drinkable water is found underground and is 0.2%.
- The remaining 2.14% is in the form of ice sheets and glaciers.
- About 70% of the earth surface is covered with water.

Distribution of water

Sources/Reservoirs		Percentage	
Oceans		97.5%	
Fresh Water	Lakes	2.5%	0.4%
	Ground water		30.9%
	Glaciers and ice caps		68.7%

Q.2 Enlist the importance of water.

Ans. Importance of water

The following points depict the importance of water.

- Water is a symbol of life.
- Where ever there is water there is life.
- The earth is called a blue planet due the presence of water on it.
- All living beings are dependent on water for their survival.
- Human body contains approximately 70% of water by mass.
- Human blood plasma contains 92% of water.

The importance of water can be further categorized into;

Symbol of life

Water is a symbol of life. All the reactions taking place in the body of living organisms occur in the presence of water.

Thermostat

Water act as a huge thermostat as it regulates the temperature of the entire earth. Water prevents the excessive cooling or heating of the earth.

Transportation

Water provides a medium for the transportation of boats and ships. Oceans and seas are of high economic value for a country.

Universal solvent

Water acts as a universal solvent and apart from polar substances, it can dissolve even non-polar substances.

Hydel energy

Water is a source of hydel energy as it is used for moving the turbines in hydel power plants. This hydel energy is converted to electrical energy in hydel power plants.

Agricultural activities

All the agricultural activities are dependent on water. Plants cannot be grown in the absence of water.

Industrial use

Water is used in industries and factories for various purposes.

Aquatic life

Aquatic plants and animals are highly dependent on water. Water provides an ecosystem for their survival.

Q.3 Explain the anomalous expansion/behaviour of water. Also explain why water possesses such property? OR Why ice floats on the surface of water?

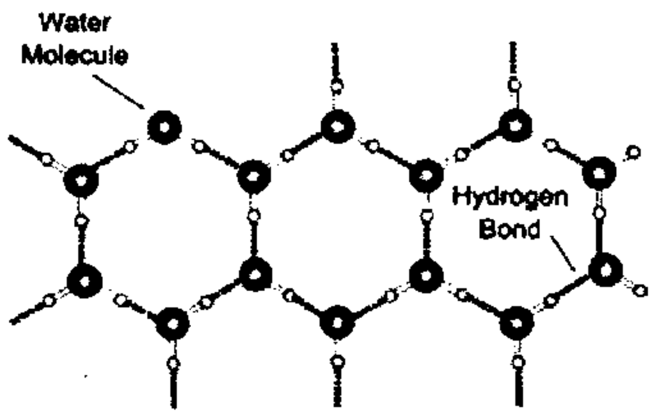
Ans. **Anomalous behaviour of water**

Unlike other liquids, water shows a unique behaviour towards the change in temperature, this unique behaviour of water is called anomalous behaviour of water.

- Generally, it has been observed that the density of liquids increases with the decrease in temperature.
- Like other liquids, density of water also increases with decrease in temperature and becomes $1 g/cm^3$ at 4^0C.
- But if the temperature of water is decreased, further down from 4^0C, the density of water decreases and attain a value of $0.91\ g/cm^3$.
- At 0^0C, as water converts to ice and the density of ice ($0.91\ g/cm^3$) is less than the density of water ($1 g/cm^3$) therefore, ice floats on the surface of water.
- This unique behaviour of water is called anomalous behaviour of water.

Reason for anomalous behaviour

- Hydrogen bonds of water in liquid state are non-permanent.
- The formation and deformation of hydrogen bonds occur continuously.
- At 0°C, hydrogen bonds attain a permanent position and they do not get broken any more.
- As a result, water molecules form a hexagonal structure in solid state.



Hexagonal Structure of water molecules in frozen state (ice)

- In hexagonal structure, six water molecules arrange themselves in the form of a ring, having empty space in the middle and occupying a large volume.
- As density is inversely proportional to volume, therefore the density of water decreases at 0°C.

Q.4 What is meant by water quality? How can we maintain its quality?

Ans. Water Quality

Water quality is defined on the bases of its physical, chemical, biological and radiological characteristics and suitability for use. There are various parameters, which are responsible for the quality of water. These parameters include

- pH of water
- hardness
- total dissolved solids
- biological oxygen demand (BOD)
- Chemical oxygen demand (COD) etc.

All these parameters should be according to the permissible limits issued by World Health Organization (WHO). Otherwise the higher or lower concentration of these parameters can make the water polluted and unfit for drinking purpose.

Water is polluted from various natural and anthropogenic activities. Polluted water causes serious health problems such as intestinal diseases, Hepatitis C, autism etc.

Maintaining Water quality

The quality of water can be maintained by promoting awareness among masses. People must be educated about the harmful aspects of adding wastes and toxic substances to water sources.

Q.5 Describe the composition of water.

Ans. Composition of water

Water was thought to be an element, but, in 1776 Henry Cavendish proved experimentally that water is a compound of hydrogen and oxygen.

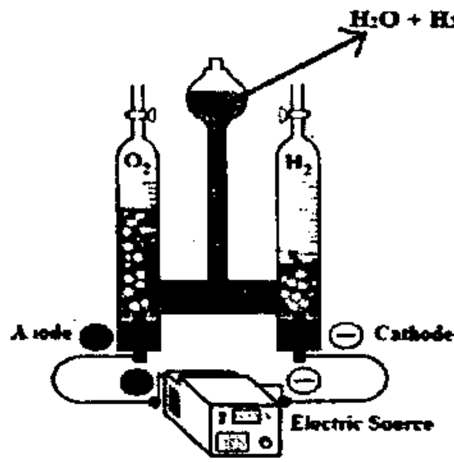
Composition of water can be determined by both:

- Volume
- Mass

i. Composition of water by volume

The composition of water by volume can be determined by an apparatus known as Hofmann's

Voltammeter.The electrolytic study of water in Hofmann's Voltammeter shows that water contains two part of hydrogen and one part of oxygen by volume.The electrolysis of water is carried out by passing current through acidified water.



Hoffman's Voltameter

ii. <u>Composition of water by Mass</u>

The composition of water by mass was determined by Josep Proust.He proved experimentally that the ratio of hydrogen to oxygen in water is 1:8 by mass.The percentage composition of both the elements also shows the same result.

<u>Percentage composition</u>

For finding percentage composition consider the molecular formula of water i.e. H_2O.

<u>Molar Mass of H_2O</u>

Atomic Mass of Hydrogen = 1

Atomic Mass of Oxygen = 16

Molar Mass

$H_2 = 1 \times 2 = 2$

$O = 16 \times 1 = 16$

Molar mass= 18 g

$$\text{Percentage of hydrogen} = \frac{\text{Molecular Mass of Hydrogen}}{\text{Molar Mass of } H_2O} \times 100$$

Putting values

$$\text{Percentage of hydrogen} = \frac{2}{18} \times 100 = 11.11\ \%$$

$$\text{Percentage of oxygen} = \frac{\text{Molecular Mass of Hydrogen}}{\text{Molar Mass of } H_2O} \times 100$$

Putting values

$$\text{Percentage of oxygen} = \frac{16}{18} \times 100 = 88.88\%$$

Percentage ratio

H :O
11.11:88.88
1 :8

Q.6 Describe the physical properties of water.

Ans. Physical properties of water

The properties of water are given as under;

Taste, Colour and Odour

Pure water is colourless, odourless and tasteless.

Physical State

Water exists in all three states of matter i.e. liquid, solid and gas.

Freezing Point and B.P

Freezing point of water is 0°C and boiling point is 100°C.

pH

Pure water is neutral. It is neither acidic nor basic. It does not change the colour of litmus paper.

Conductivity

Pure water is poor conductor of electricity. Its conductivity is due to the dissolved electrolytes.However, Water is a good conductor of heat than other liquids.

Polarity

The molecule of water is polar.

Density

Density of pure water is $1g/cm^3$.

Heat Capacity

Heat capacity of water is 4.18 J/g °C.

Surface Tension

It has a high surface tension value of 72 dynes/cm.

Latent Heat of Fusion

Latent heat of fusion of water is 6 kJ/mol.

Latent Heat of Vaporization

Latent heat of vaporization of water is 41 kJ/mol at 100°C.

Q.7 Write down the chemical properties of Water.

Ans. **Chemical Properties of water**

The chemical properties of water are categorized into the following main points.

a. **Thermal Stability of water**

It has been found experimentally that only one percent of molecule of water decomposes to hydrogen (H_2) and oxygen (O_2) at 2000°C. This shows the thermal stability of

water.

Chemical Reaction

$$2H_2O_{(g)} \xrightarrow{2000^\circ C} H_{2(g)} + O_{2(g)}$$

b. **Reaction with metals**

Reaction of water with metal is extremely exothermic. It releases a huge amount of energy in the form of heat.Reaction of water with Alkali and Alkaline earth metal leads to the formation of hydrogen gas.

Reaction with metals can be categorized into following:

i. **Reaction with Alkali Metals**

Metals of 1st group are called alkali metals. First group metals like Lithium (Li), Sodium (Na), Potassium (K) etc react with water to form their respective hydroxides and hydrogen gas.

Chemical Reaction

$$2Na_{(s)} + H_2O_{(l)} \longrightarrow 2NaOH_{(aq)} + H_{2(g)}$$

$$2K_{(s)} + H_2O_{(l)} \longrightarrow 2KOH_{(aq)} + H_{2(g)}$$

The reaction becomes more vigorous as we go down the group in alkali metals.

ii. **Reaction with Alkaline earth Metals**

Metals of 2nd group are called Alkaline earth metals. These metals may be beryllium (Be), calcium (Ca) and magnesium (Mg) etc.

Calcium react with water on heating to produce $Ca(OH)_2$ and hydrogen (H_2) gas.

Chemical Reaction

The reaction is given as under.

$$Ca_{(s)} + 2H_2O_{(l)} \longrightarrow Ca(OH)_{2(aq)} + H_{2(g)}$$

Magnesium does not react with cold and hot water. It

reacts with steam to form magnesium oxide and hydrogen gas.

$$2Mg_{(s)} + 2H_2O_{(g)} \longrightarrow 2MgO_{(s)} + 2H_{2(g)}$$

iii. **Reaction with other Metals**

Metals like Copper, Mercury, Gold and Platinum do not react with water at ordinary conditions.However, metals like zinc (Zn) and iron (Fe) also react with water to form hydrogen gas.Zinc does not react with hot or cold water rather it reacts with steam to form zinc oxide and hydrogen gas.

Chemical Reaction

$$2Zn_{(s)} + 2H_2O_{(g)} \longrightarrow 2ZnO_{(s)} + 2H_{2(g)}$$

Metal like iron also react with water to form magnetic iron oxide (Fe_3O_4).

$$3Fe_{(s)} + 4H_2O_{(g)} \longrightarrow Fe_3O_{4(s)} + 4H_{2(g)}$$

c. **Reaction with non-metals**

The reactions of water with non-metals are described as under:

i. **Reaction with Chlorine**

Chlorine is generally used as disinfectants for water disinfection. Chlorine based disinfectants are most commonly used for maintaining a clean swimming pool. Chlorine reacts with water to form hydrochloric acid (HCl) and hypochlorous acid (HOCl). HOCl is unstable and is converted to HCl and atomic oxygen, which can decolorize the stain and can kill the germs, therefore, chlorine is used as bleaching agent and as germicide.

Chemical Reaction

$$Cl_{2(g)} + H_2O_{(l)} \longrightarrow HCl_{(aq)} + HOCl_{(aq)}$$

$$HOCl_{(aq)} \longrightarrow HCl_{(aq)} + [O]$$

ii. **Reaction with carbon**

Water in the form of steam reacts with red-hot carbon to produce a mixture of carbon monoxide and hydrogen gas.

Chemical Reaction

$$C_{(s)} + H_2O_{(g)} \longrightarrow CO_{(s)} + H_{2(g)}$$

This mixture of carbon monoxide and hydrogen gas is known as water gas. Water gas is used as fuels.

iii. **Reaction with silicon**

Silicon reacts with steam at high temperature to form silicon oxide (silica) and hydrogen gas.

Chemical Reaction

$$Si_{(s)} + 2H_2O_{(g)} \longrightarrow SiO_{2(s)} + 2H_{2(g)}$$

iv. **Reaction with sulphur**

Sulphur reacts with steam to form hydrogen sulphide and sulphur dioxide. The reaction is given as under.

Chemical Reaction

$$3S_{(s)} + 2H_2O_{(g)} \longrightarrow 2H_2S_{(g)} + SO_{2(s)}$$

d. **Reaction with metallic oxides**

Metallic oxides like sodium oxide, calcium oxide, magnesium oxide etc., react with water to form their respective hydroxides.

i. **Reaction with Sodium oxide**

Water reacts with sodium oxide to form sodium hydroxide.

Chemical Reaction

$$Na_2O_{(s)} + H_2O_{(l)} \longrightarrow 2NaOH_{(aq)}$$

ii. **Reaction with Calcium oxide**

Calcium oxide is commonly known as quick lime.

Water reacts with calcium oxide; calcium oxide is converted to calcium hydroxide. Calcium hydroxide is commonly known as slaked lime.

Chemical Reaction

$$CaO_{(s)} + H_2O_{(l)} \longrightarrow Ca(OH)_{2(aq)}$$

e. Reaction with non-metallic oxides

Reaction of water with non-metallic oxides like carbon dioxide, nitrogen dioxide, sulphur trioxide etc., gives their respective acids.

i. Reaction with carbon dioxide

Water reacts with carbon dioxide to form carbonic acid.

Chemical Reaction

$$H_2O_{(l)} + CO_{2\,(g)} \longrightarrow H_2CO_{3(aq)}$$

This reaction is responsible for acid rain due to oxides of carbon.

ii. Reaction with Nitrogen peroxide

Water reacts with Nitrogen peroxide (N_2O_4) to form nitric acid. Nitrogen per oxide (N_2O_4) is dimer of nitrogen dioxide (NO_2) i.e. $N_2O_4 = 2NO_2$.

Chemical Reaction

$$H_2O_{(l)} + N_2O_{4\,(g)} \longrightarrow HNO_{3(aq)} + HNO_{2(aq)}$$

iii. Reaction with sulphur trioxide

Water reacts with sulphur trioxide to form sulphuric acid. This reaction is also responsible for acid rain due to oxides of sulphur.

Chemical Reaction

$$H_2O_{(l)} + SO_{3\,(g)} \longrightarrow H_2SO_{4(aq)}$$

f. Hydrolysis Reaction

The reaction in which the H-OH bond of water molecule is broken down by the action of a salt is called hydrolysis reaction. Hydrolysis reaction is the reverse of neutralization reaction. The reaction of a salt with water makes the solution either acidic or basic.

Basic solution:

If a salt formed from the reaction of weak acid and strong base is dissolved in water, the solution formed will be basic solution.

Example:

Sodium acetate (CH_3COONa) is a salt which is formed as a result of neutralization reaction of weak acid i.e. CH_3COOH and strong base i.e. NaOH.

When sodium acetate reacts with water, basic solution is formed.

Chemical Reaction

$$CH_3COONa_{(aq)} + H_2O_{(l)} \longrightarrow \underset{\text{Weak acid}}{CH_3COOH_{(aq)}} + \underset{\text{Strong base}}{NaOH_{(aq)}}$$

Acidic Solution:

If a salt formed from the reaction of strong acid and weak base is dissolved in water, the solution formed will be acidic solution.

Example:

NH_4Cl is a salt which is formed as a result of neutralization reaction of weak base i.e. NH_4OH and strong acid i.e. HCl

When NH_4Cl reacts with water, acidic solution is formed.

Chemical Reaction

$$NH_4Cl_{(aq)} + H_2O_{(l)} \longrightarrow \underset{\text{Weak base}}{NH_4OH_{(aq)}} + \underset{\text{Strong acid}}{HCl_{(aq)}}$$

Q.8 Water is a universal solvent. Why?

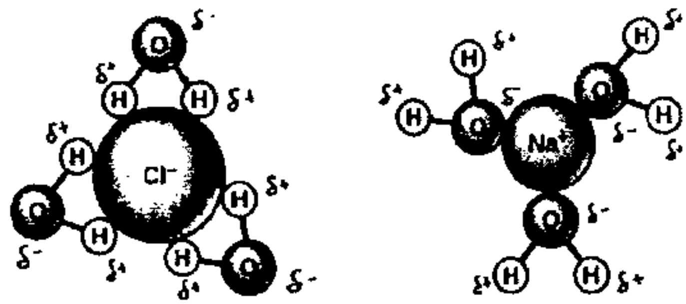
Ans. Water is a universal solvent as it can dissolve more substances than any other solvent. It can dissolve many inorganic compounds and certain organic compounds. This is due to the following reasons.

- Polarity of water molecules
- Hydrogen bonding
- Dielectric constant

Polarity of water Molecules

- Water is polar in nature because the electro-negativity of hydrogen is 2.1 and that of oxygen is 3.5.
- Due to this higher electro-negativity difference the hydrogen of H_2O is bearing partial positive charge and the oxygen of H_2O is bearing partial negative charge.
- Due to this polar nature of water it can dissolves certain ionic compounds.
- When an ionic compound is added to water the positive part of ionic compound is surrounded by the partially negative charged oxygen and the negative part of the ionic compound is surrounded by the partially positive charged oxygen, resulting into the breaking up of an ionic compound.
- NaCl, KCl, Na_2CO_3 are ionic compounds that follow the mechanism given above for their solubility.

Diagram



Hydrogen bonding in water

- Covalent compounds are soluble in water, because water molecules possess hydrogen bonding.
- Hydrogen bonding is the intermolecular force of attraction of hydrogen of one molecule with an electronegative atom (Nitrogen, Oxygen,and Fluorine) of another molecule.
- As Oxygen of water molecules is electronegative specie that possess two lone pairs of non-bonding electrons therefore water molecule (H_2O) forms four hydrogen bonds with other water molecule.
- When a covalent compound containing polar ends are added to water it forms hydrogen bond with water and get dissolved.
- Sugar $C_6H_{12}O_6$ and Methyl alcohol CH_3OH despite of being organic in nature are soluble in water due to the formation of hydrogen bonds.
- Covalent compounds that do not have polar ends such as alkanes, alkenes, benzene, ether etc are insoluble in water.

Dielectric constant Value

According to Coulombs law,"the force of attraction or

repulsion between two charges is directly proportional to the product of magnitude of the charges and inversely proportional to the square of the distance between them".

Mathematically,

$$\text{Force} \propto \frac{Q_1Q_2}{r^2}$$

$$\text{Force} = \frac{1}{D}\frac{Q_1Q_2}{r^2}$$

$$F = \frac{Q_1Q_2}{Dr^2} \quad \ldots\ldots. 1$$

Where, "D" is proportionality constant that is called dielectric constant.

Dielectric constant definition:

It is the ratio of the amount of electrical energy stored in a material by an applied voltage to the electrical energy stored in a vacuum.Dielectric value is dependent on the medium in which both the charges are kept. It is obvious from equation 1 that greater the value of "D" lesser will be the force of attraction or repulsion between the charges.

As the Dielectric constant value of water is 80 at 18^{0}C therefore the ions of a polar solvent will have less force of attraction and will be easily separated from one another and will be dissolved.The force of attraction between the ions will be greater if dissolved in those liquids which have less dielectric value. They will not be separated easily and will not be dissolved.

Q.9 What is meant by soft water and hard water? Describe the causes of hardness of water.

Ans. Soft Water

- The water which easily produces lather with soap is

called soft water.

- Soft water does not waste soap and dirt and stains are easily removed easily.

Hard Water

- The water which does not produce lather with soap and produces scum with soap is called hard water.
- Hard water forms curd with soap and affects the cleaning action of soap.
- Hard water wastes soap and it is difficult to remove dirt and stains with hard water.

Causes of Hardness

The hardness of water is due to the presence of soluble salts like

- Bicarbonates of Calcium and Magnesium
  - Calcium bicarbonate $Ca(HCO_3)_2$
  - Magnesium bicarbonate $Mg(HCO_3)_2$
- Chlorides and sulphates of Ca and Mg
  - Calcium chloride $CaCl_2$
  - Magnesium chloride $MgCl_2$
  - Calcium sulphate $CaSO_4$
  - Magnesium sulphate $(MgSO_4)$

Rocks of Gypsum $CaSO_4.2H_2O$ and Limestone are present inside the earth. Rain water dissolves Carbon dioxide (CO_2) from the atmosphere. Rain water containing carbon dioxide has the ability to dissolve a small amount of $CaCO_3$ to form Calcium bicarbonate. Similarly, it has the ability to dissolve a small amount of $MgCO_3$ also forming Magnesium bicarbonate.

Chemical Reactions

The reactions are given below:

$$CaCO_{3(s)} + CO_{2(g)} + H_2O_{(l)} \longrightarrow Ca(HCO_3)_{2(aq)}$$

$$MgCO_{3(s)} + CO_{2(g)} + H_2O_{(l)} \longrightarrow Mg(HCO_3)_{2(aq)}$$

Q.10 Write down the types of hard water.

Ans. Hard water is of two types i.e.

- Temporary hard water
- Permanent hard water

Temporary Hard Water

It is that type of hardness of water, which is due to the presence of dissolved calcium bicarbonate and magnesium bicarbonate in water.

The salts of $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$ are soluble in water and are present in the form of dissociated ions i.e. positive and negative ions.

$$Ca(HCO_3)_{2(aq)} \longrightarrow Ca^{2+} + 2HCO_3^-{}_{(aq)}$$
$$Mg(HCO_3)_{2(aq)} \longrightarrow Mg^{2+} + 2HCO_3^-{}_{(aq)}$$

Permanent Hard Water

It is that type of hardness of water, which is due to the presence of dissolved chlorides and sulphates of calcium and magnesium in water.

These salts are given below:

- Calcium chloride($CaCl_2$)
- Magnesium chloride($MgCl_2$)
- Calcium sulphate($CaSO_4$)
- Magnesium sulphate($MgSO_4$)

These salts are soluble in water and are present in the form of dissociated ions in water.

$$CaCl_{2(aq)} \longrightarrow Ca^{2+} + 2Cl^-{}_{(aq)}$$
$$MgCl_{2(aq)} \longrightarrow Mg^{2+} + 2Cl^-{}_{(aq)}$$
$$CaSO_{4(aq)} \longrightarrow Ca^{2+} + SO_4^{-2}{}_{(aq)}$$

$$MgSO_{4(aq)} \longrightarrow Mg^{2+} + SO_4{}^{-2}{}_{(aq)}$$

Q.11 How temporary hardness of water can be removed?

Ans. The two methods commonly used for the removing of temporary hardness of water are:

- By boiling temporary hard water
- Clark's Method

i. Boiling Method

The temporary hardness of water can be removed by simple boiling the water.As temporary hardness of water is caused by the presence of Bicarbonates of Calcium and Magnesium, therefore heating temporary hard water converts the soluble salts of calcium and magnesiumi.e. $Ca(HCO_3)_{2(aq)}$and $Mg(HCO_3)_{2(aq)}$, to insoluble salts such as $CaCO_3$ and $MgCO_3$.These salts being insoluble settle down at the bottom in the form of precipitates.

Chemical Reactions

$$Ca(HCO_3)_{2(aq)} \xrightarrow{\text{boiling}} CaCO_{3\,(s)} + CO_{2\,(g)} + H_2O_{(l)}$$

$$Mg(HCO_3)_{2(aq)} \xrightarrow{\text{boiling}} MgCO_{3\,(s)} + CO_{2\,(g)} + H_2O_{(l)}$$

ii. Clark's Method /Chemical Method

This method is used for the removing of temporary hardness of water on a large scale.In this method a specific amount of slaked lime $Ca(OH)_2$ is added to water. As a result,the soluble bicarbonates (HCO_3^-) of calcium and magnesium are converted into insoluble carbonates (CO_3^{-2}). The insoluble $CaCO_3$and $MgCO_3$ settle down at the bottom in the form of precipitates.

Chemical Reactions

The chemical reactions are given as under:

$$Ca(HCO_3)_{2(aq)} + Ca(OH)_2 \longrightarrow 2CaCO_{3(s)} + 2H_2O_{(l)}$$

$Mg(HCO_3)_{2(aq)} + Ca(OH)_2 \longrightarrow MgCO_{3(s)} + 2CaCO_{3(s)} + 2H_2O_{(l)}$

Q.12 How permanent hardness of water can be removed?

Ans. The permanent hardness of water can be removed only by using chemicals. The two methods commonly used for the removing of permanent hardness of water are:

- By using washing soda
- Ion exchange method

i. By using washing soda

In this method, permanent hard water is treated with the washing soda (Na_2CO_3). As a result, the soluble salts such as chlorides and sulphates of calcium and magnesium are converted to insoluble salts and precipitate at the bottom.

Chemical Reactions

$$Na_2CO_{3(aq)} + CaCl_{2(aq)} \longrightarrow CaCO_{3(s)} + 2NaCl_{(aq)}$$

$$Na_2CO_{3(aq)} + MgCl_{2(aq)} \longrightarrow MgCO_{3(s)} + 2NaCl_{(aq)}$$

$$Na_2CO_{3(aq)} + CaSO_{4(aq)} \longrightarrow CaCO_{3(s)} + Na_2SO_{4(aq)}$$

$$Na_2CO_{3(aq)} + MgSO_{4(aq)} \longrightarrow MgCO_{3(s)} + Na_2SO_{4(aq)}$$

ii. Ion Exchange Method

- In this method, the permanent hardness of water is removed by a displacement reaction.
- An ion exchange resin namely zeolite, is used in this method.
- Zeolite is commonly known as sodium zeolite.
- It is a naturally occurring sodium aluminium silicate.
- It can also be prepared artificially.
- The method is used both at consumer level and on industrial level.

Mechanism

Sodium zeolite is fitted in the path of hard water in a column. When hard water is passed from the zeolite, an ion exchange reaction takes place.As a result, the sodium ions in the zeolite are replaced bycalcium ions and magnesium ions of the soluble salt (causing permanent hardness in water), while sodium is transferred into the solution where it takes the place of calcium and magnesium.

Chemical Reactions

The reactions are given below;

$$CaSO_{4(aq)} + Na_2\text{-Zeolite} \longrightarrow Ca\text{-Zeolite} + Na_2SO_{4(aq)}$$

$$MgSO_{4(aq)} + Na_2\text{-Zeolite} \longrightarrow Mg\text{-Zeolite} + Na_2SO_{4(aq)}$$

$$CaCl_{2(aq)} + Na_2\text{-Zeolite} \longrightarrow Ca\text{-Zeolite} + 2NaCl_{(aq)}$$

$$MgCl_{2aq)} + Na_2\text{-Zeolite} \longrightarrow Mg\text{-Zeolite} + 2NaCl_{(aq)}$$

Reactivation of Sodium Zeolite

The regular use of Na_2-Zeolite makes it inactive. For reactivation, the inactive zeolite is kept in a strong solution of sodium chloride (NaCl). As a result, sodium zeolite reactivates by ion exchange reaction.

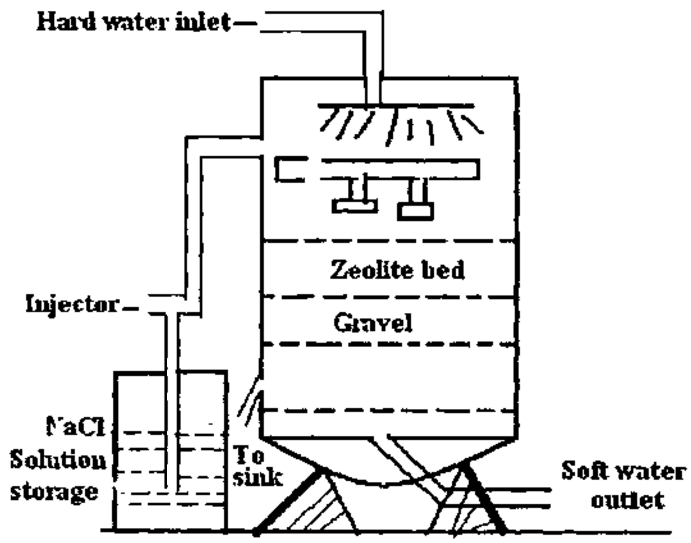
Chemical Reactions

The reaction is given below.

$$Ca\text{-Zeolite} + 2NaCl \longrightarrow Na_2\text{-Zeolite} + CaCl_{2(aq)}$$

If inactive zeolite is containing Magnesium, then the reaction will be;

$$Mg\text{-Zeolite} + 2NaCl \longrightarrow Na_2\text{-Zeolite} + MgCl_{2(aq)}$$



Ion-exchange Method

Q.13 Enlist the disadvantages of hard water.

Ans. Following are the disadvantages of hard water;

Wastage of soap

Hard water produces scum and curd with soap and affects the cleaning action of soap. Dirt and stains cannot be washed with hard water. It consumes a large amount of soap in washing process.

Reduces Boilers life

Hard water is not suitable for using in boilers (important in many industries) and steam engines because:

- Excessive heating converts the soluble salts into insoluble salts.
- The insoluble salts get precipitated in the boilers in the form of hard insulating layers.
- Due to the presence of these insulating layers of salts in the boilers, excessive fuel is consumed to generate

enough heat for producing steam.

- That reduces the life of boilers and leads to a constant threat of boilers explosion.

Stomach problem

Hard water causes dysentery, intestinal and stomach diseases, if used for drinking purposes for a long time.Magnesium sulphate usually present in hard water weakens the function of stomach.

Q.14 What is meant by water pollution? Write down the source of water pollutants.

Ans. Water pollution

Water pollution is the introduction of undesirable substances to water, which makes the water contaminated and unfit for drinking purposes.

Sources of water pollution

- Various natural and anthropogenic activities are adding several water pollutants to water.
- It is not suitable for drinking purposes and causes several water borne diseases.
- According to World Health Organization (WHO) about 80% of the diseases are caused by polluted water.
- The reservoirs of fresh water are limited therefore; it is a dire need of the day to save water from pollution.

Water Pollutants

The major sources of water pollutants are categorized into;

- Industrial wastes
- Household wastes
- Agricultural wastes

- Animal wastes

Industrial wastes

One of the major sources of water pollution is industrial bloom.

- In order to fulfill the needs of the masses, various industries are started without proper planning and waste treatment. Their wastes are disposed directly to water, which are highly toxic in nature and can cause serious threats to the life of living organisms.
- The most common industries are plastic, textile, paper, petrochemical, oil refining, fertilizer and leather industries. The industrial wastes commonly disposed-off in water by industries are mercury (Hg), cadmium (Cd), lead (Pb), chromium (Cr), acids, oils, greases, dyes and many more substances.
- These wastes are absorbed by ground water and hence the water becomes polluted.
- Polluted water has catastrophic effects on the life of living beings and causes several water-borne diseases. This polluted water cause death, birth defects and mental problems when enters a food chain.
- Besides this, heated water from industries destroys aquatic life. In addition, untreated water causes typhoid, cholera, hepatitis, pneumonia and dysentery.

Household wastes

Wastes disposed to fresh water from the houses are called household wastes.These wastes may be produced while using different chemicals such as soaps, detergents, shampoos, drain-openers, bleaches etc.

Household wastes can be broadly classified into two categories.

- Waste water
- Solid wastes

Waste water

- Water from kitchens, washrooms etc collectively form wastewater.
- We used different chemicals at home in the form soaps, detergents, shampoos, bleaches, hair colours, dyes etc. Wastes water containing these wastes, affects the quality of water and aquatic life. Such polluted water causes cholera, typhoid, dysentery and other intestinal disease among human beings.

Solid wastes

- Solid waste is also called domestic wastes or urban wastes.
- Various solids and semisolids wastes such as food, newspaper, bottles, cans, wrappers, plastics etc., are added to streams, lakes and rivers, which makes the water polluted.
- Besides this if these wastes are dumped on the earth surface, the rainwater absorbs or extract chemicals from these wastes resulting into a mixture of different chemicals.
- This resultant of different mixture is called leachate and the process is called leaching.
- Leachate can pollute underground water when seeps into the soil.
- It can also affect aquatic life when it finds its way to rivers and streams with rainwater.

Agricultural wastes

The wastes produced as a result of various agricultural activities are called agricultural wastes.

Agricultural wastes are of two types i.e.

- Natural wastes
- Synthetic wastes

Natural wastes

Example of naturals wastes are wastes from animal's manure, wastes from harvesting, wastes from poultry, slaughterhouses etc.

Synthetic wastes

Synthetic wastes include wastes from using insecticide, pesticides, herbicides etc.It also includes wastes from different synthetic fertilizers.The above two types of wastes pollute water and affect aquatic life when drained from fields to rivers and streams.

Animal wastes

Animal wastes include dung, animal dander, animal manure, bloods from slaughterhouses etc.In most of the cases, animals are raised in residential areas.Their wastes are not properly treated. They are added directly to water, which makes the water polluted.

Q.15 What do you know about water borne diseases? How they are classified?

Ans. **Water borne diseases**

The diseases caused by drinking polluted water or from the food prepared in polluted water are called water borne diseases. Water is a symbol of life. Life is not sustainable without water.Pure water ensures health, but polluted water has adverse effects on health.

According to World Health Organization, about 80% diseases are caused by drinking polluted water. Moreover, 1.8 million people die of diarrheal disease every year. Diarrheal diseases are caused by drinking polluted water. Mortality rate is increasing due to waterborne diseases.

Classification of water borne diseases

Water borne diseases are classified into the following types;

Bacterial infection

Cholera, dysentery and typhoid fever are the diseases caused by bacterial infection.

i. **Cholera**

- It is an intestinal disease.
- Symptoms of cholera are watery diarrhoea and vomiting.
- Cholera can lead to dehydration of the body and electrolytic imbalance.
- It can cause even death if not treated in time.

ii. **Dysentery**

- Dysentery is an infectious disease associated with severe diarrhoea.
- Dysentery may be amoebic dysentery or bacillary dysentery.
- It is a large intestinal disease.
- It causes abdominal cramps, anal pain and bloody stool.

iii. **Typhoid**

- It is a waterborne disease caused by a bacterium called *Salmonella Typhae.*

- This bacterium enters the blood stream causing infection of typhoid fever.

Viral infections

Hepatitis A, hepatitis E and polio are the examples of viral diseases that are caused by drinking polluted water

i. **Hepatitis A**

- It is a highly contagious liver infection, which is caused by hepatitis A virus.
- Hepatitis A virus affects liver's functions.
- Hepatitis A is mostly caused by eating contaminated food or drinking contaminated water.
- Symptoms of hepatitis A are fatigue, nausea, vomiting, abdominal pain and loss of appetite. Yellowing of the skin and the whites of your eyes also occur in this disease.

ii. **Hepatitis E**

- Hepatitis E virus also infects liver.
- It can cause swelling of liver.
- It is caused by drinking polluted water.
- Hepatitis E is more common in those countries where there is scarcity of clean water.
- Symptoms of hepatitis E are mild fever, fatigue, loss of appetite, belly pain, dark pee
- Yellowish skin or eyes etc.

iii. **Polio**

- It is a contagious viral disease.
- It may cause nerve injury that leads to paralysis called acute flaccid paralysis (AFP).

- It may also cause difficulty in breathing and sometimes death.
- It is also known as Poliomyelitis.
- Poliovirus enters the environment from the faeces of infected person.
- Poliovirus lives in throat and intestine, it can be transmitted through cough or sneeze.
- It is easily spread through contaminated water.

Protozoal infections

The most common protozoal infections include Amoebiasis and Giardiasis.

i. Giardiasis

It is an intestinal infection of a microscopic parasite that is found in areas with poor sanitation and unsafe water.Symptoms of giardiasis are abdominal cramps, bloating, nausea and bouts of watery diarrhea.

ii. Amoebiasis

It is an infectious disease that is caused by *Entamoeba histolytica*.It enters the body by eating contaminated food or drinking contaminated water.

Parasitic infections

Common examples of parasitic infections are Guinea worm infection and pinworm infection.

i. Guinea worm

- Guinea worm disease is also called Dracunculiasis disease.
- It is caused by a patristic worm called *Dracunculusmedinensis*.
- It is caused by swallowing the eggs of this worm in

contaminated water or eating spoiled food.

- The worm breaks through the skin after spending a year inside the body, which causes burning, itching, pain, and swelling of that part of the body where the worm is present in the body.
- Ulcers, fever, vomiting, nausea etc., may also occur.

ii. **Pin Worm**

- It is the most common type of intestinal worm infection.
- It is caused by swallowing the eggs of pin worm through contaminated water.
- Most of the people have no symptoms, but in some people, it may cause anal itching and restless sleep.

Arsenicosis and fluorosis

Water containing excess minerals such as Arsenic and Fluoride can cause these diseases.

i. **Arsenicosis**

- It is caused by drinking water containing high level of Arsenic (As).
- It is also known as arsenic poisoning.
- Symptoms of this disease include excess of saliva, vomiting, nausea, blood in urine etc.
- The permissible limit of Arsenic in water according to World Health Organization (W.H.O) is 0.01 mg/dm^3

ii. **Fluorosis**

- It is a disease caused by drinking water with excess fluoride.
- It damages the bones and teeth.

Q.16 Describe the effects of water pollutants.

Ans. **Effects of water pollutants**

Water pollutants have harmful effects on human beings, plants and animals.Polluted water is not suitable for drinking as well as irrigation purposes.

The harmful effects of Water pollutants are categorized as;

i. Infectious Disease

- Polluted water contains viruses, bacteria and protozoans which cause various infectious diseases.
- These Infectious diseases include typhoid, cholera, dysentery, amoebiasis, ascariasis, hepatitis etc.

ii. Nutrient Pollution/ Eutrophication

- Eutrophication is the enrichment of water with nutrients such as nitrogen, phosphorous, potassium and nitrates.
- Agricultural fields generally contain Nitrogen, Phosphorous, potassium and other nutrients.
- Water flowing from agricultural fields towards drains, streams, ponds etc. is enriched with these nutrients.
- These excessive amounts of nutrients in water enhance the production of algae and other phytoplankton.
- These algae and phytoplankton utilize oxygen for their growth and development, thus, a decrease in the total dissolved oxygen occurs in aquatic ecosystem that can cause death of aquatic organisms.

iii. Chemical Contamination

- Chemical contamination is a broad term; some contamination is due to pesticides, herbicides, insecticides, heavy metals, oils etc.

- Water contaminated with pesticides (heavily used in agricultural crops) affects nervous system, liver, reproductive system etc.
- Polluted water containing oil and petrochemicals destroy the habitat for aquatic organisms. They cause gastro-intestinal irritation, liver and kidneys disorders, and can also damage nervous system.
- Mercury (Hg) is a toxic metal that is used in various industries. Polluted water or food containing mercury can cause brain damage, learning defects, incomplete mental development. It can cause Parkinson's disease and Alzheimer's disease in human beings.

iv. <u>Thermal Water Pollution</u>

- Thermal water pollution refers to the high temperature water coming from various industries.
- Many aquatic organisms die of hot water because they cannot survive above 30^0C.
- Hot water also decreases the solubility of oxygen in water causing the death of aquatic organisms due to the scarcity of dissolved oxygen in water.

EXERCISE

A. Choose the correct option.

1. Water has the ability to dissolve non ionic polar compounds due to

   a. Ionic forces b. Dipole-dipole forces

   c. Ionic-dipole forces d. Hydrogen bonding

2. All salts cause the water become hard except

   a. Calcium chloride b. Calcium bicarbonate

c. Magnesium sulphate d. Sodium chloride

3. The salt which causes temporary hardness in water is
   a. Magnesium sulphate b. Calcium chloride
   c. Magnesium chloride d. Calcium bicarbonate
4. Chlorine acts as bleaching agent in the presence of
   a. HCl b. H_2O
   c. NaOH d. HNO_3
5. Permanent hardness of water is removed by adding
   a. Washing soda b. Soda lime
   c. Caustic soda d. Baking soda
6. Most of the aquatic animals cannot survive in water above,
   a. 20 °C b. 25 °C
   c. 30 °C d. 35 °C
7. The density of water is maximum at
   a. −40°C b. 40°C
   c. −4°C d. 4°C
8. The disease which cause liver infection
   a. Hepatitis b. Cholera
   c. Typhoid d. Dysentery
9. All are waterborne disease except
   a. Hepatitis b. Malaria
   c. Typhoid d. Dysentery
10. Water gas is a mixture of
   a. CO and H_2 b. C and H_2
   c. CO and H_2O d. C and H_2O

ANSWERS:

1	d	2	d	3	d	4	b	5	a
6	c	7	d	8	a	9	b	10	a

B. Write short answers to the following questions.

Q.1 Identify the factors that are responsible for dissolving polar substances in water.

Ans. See Question 8

Q.2 Explain why it is advisable to drink boiled water.

Ans. It is advisable to drink boiled water because boiling water kills the disease-causing microorganisms. Water may contain harmful bacteria that can cause digestive problems like cholera and dysentery. Therefore, boiling water makes it free from microbes to some extent.It has been found that maximum microbes cannot survive above 160^0F.

Besides this, boiling water also removes temporary hardness of water, as the soluble bicarbonates are converted to insoluble carbonates, which settle down in the form of precipitate.

Q.3 Why Ice floats on the surface of water?

Ans. Like other liquids, the density of water increases with decrease in temperature and attains a maximum value of 1g/cm^3 at 4^0C.But, if the temperature of water is decreased further down from 4^0C, the density of water decreases and attains a value of 0.91 g/cm^3 at 0^0C.

This unique behaviour of water is called anomalous behaviour of water.At 0^0C, as water converts to ice and the density of ice (0.91 g/cm^3) is less than the density of water (1g/cm^3) therefore, ice floats on the

surface of water.

Q.4 Explain the importance of water and its quality.

Ans. See Question 2 and Q.4

Q.5 What is eutrophication? How does it Pollute water?

Ans. See Question 16 (Topic: Eutrophication)

Q.6 How chemistry helps to maintain a clean swimming pool?

Ans. Chemistry helps to maintain a clean swimming pool by using chlorine-based disinfectants.It is a simple, persistent and relatively cheap method. Chlorine helps in making the swimming pool free from disease causing microbes.

<u>Mechanism of action</u>

A calculated amount of chlorine i.e. $0.5mg/dm^3$ to $1.5mg/dm^3$ is added to water.

Chlorine reacts with water, forming Hydrochloric acid (HCl) and hypochlorous acid (HOCl).

$$Cl_{2(g)} + H_2O_{(l)} \longrightarrow HCl_{(aq)} + HOCl_{(aq)}$$

Hypochlorous acid being unstable readily produces atomic oxygen [O].

$$HOCl_{(aq)} \longrightarrow HCl_{(aq)} + [O]$$

Atomic oxygen can easily kill the germs.

Q.7 Make the distinction between soft and hard water.

Ans. See Question 9

Q.8 Why water is a universal solvent?

Ans. See Question 8

Q.9 Give some disadvantages of detergents.

Ans. <u>Disadvantages of detergents</u>

- They are non-biodegradable

- They caused soil pollution.
- They can cause water pollution and affect aquatic life.
- They reduce the life of fabrics.
- They are basic in nature and are harmful to skin.

Q.10 Identify the different toxic substances in house hold wastes.

Ans. <u>Toxic substances</u>

The substances that are supposed to be poisonous and hazardous to health are termed as toxic substances.

The following items are used in our day to day life. The toxic substances they add to the household wastes are described below.

Scented candles and Air fresheners emits several carcinogens such as benzene, toluene, Para-dichlorobenzene, formaldehyde etc.

Soaps contain Formaldehyde that weakens the immune system and affects respiratory system.

Shampoos contain Polysorbate and Potassium sorbate that damages the skin.

Hair dyes contain ammonia, peroxides, diaminobenzene, resorcinol etc. These chemicals cause serious allergies of skin and eye and may cause lung irritation etc.

Plastic toys contain serious carcinogenic components like phthalates.

Batteries contain heavy metals like lead, nickel and mercury.

C. Write detailed answers to the following questions.

1. a. Enlist the main sources of water

Ans. See Question 1

b. How would you categorise the physical properties of water.

Ans. See Question 6

c. Predict the product of reaction; K, Cl_2, CaO, CH_3COONa, Cwith water

Ans. Chemical Reactions of Water

Reaction withK

$$2K_{(s)} + H_2O_{(l)} \longrightarrow 2KOH_{(aq)} + H_{2(g)}$$

Reaction withCl_2

$$Cl_{2(g)} + H_2O_{(g)} \longrightarrow HCl_{(aq)} + HOCl_{(aq)}$$

Reaction withCaO

$$CaO_{(s)} + H_2O_{(l)} \longrightarrow Ca(OH)_{2(aq)}$$

Reaction withCH_3COONa

$$CH_3COONa_{(aq)} + H_2O_{(l)} \longrightarrow CH_3COOH_{(aq)} + NaOH_{(aq)}$$

Reaction with C

$$C_{(s)} + H_2O_{(g)} \longrightarrow CO_{(s)} + H_{2(g)}$$

Q.2 Water is an excellent Solvent. Explain how this property is beneficial for life but sometimes harmful for us?

Ans. Water as a universal solvent

Water is a universal solvent as it can dissolve many substances including polar and non-polar substances. This property is very beneficial but sometimes it may be harmful for us. The advantages and disadvantages of water as a solvent are given below.

Advantages

Water as an excellent solvent is beneficial for us because of the following reasons.

- Almost all the chemical reactions necessary for the sustainability of life take place in aqueous solutions.
- Water can dissolve oxygen and many other gases thus helping in the survival of aquatic life.
- Water can dissolve nutrients from soil and carries it to roots cells.
- Almost all the solutions are made in water.
- Synthetic and natural fertilizers dissolve in water and reach to the roots of the plants.
- Certain medicinal substances are dissolved in water to be taken as medicines.
- Water is used as a solvent in many industries such as foods, medicines, fertilizers, paints, pesticides, adhesives and paper.
- We can wash cloths because water has the ability to dissolve the dirt on cloths.
- In short, all life sustaining activities, chemical reaction etc., are dependent on water.

Disadvantages

Water as an excellent solvent is sometime harmful for us because of the

- Water can be polluted easily as it dissolves toxic substances easily.
- It can dissolve minerals like nitrogen phosphorous and potassium causing eutrophication.
- Toxic substances can reach the underground water in

leaching process.

- Water can dissolve many gases like CO_2 and NO_2 etc., causing acid rain.
- Insecticides, pesticides and herbicides are soluble in water which makes the water polluted.
- Water can dissolve acidic wastes from industries which decrease the pH of water and make the survival aquatic life difficult.

Q.3 a) Classify temporary hard water and permanent hard water.

Ans. See Question 10

b) What method could be adopted to remove the temporary hardness of water?

Ans. See Question 11

c) What method could be adopted to remove the permanent hardness of water?

Ans. See Question 12

Q.4a) Why water is important for us?

Ans. See Question 2

b) Write the disadvantages of hard water.

Ans. See Question 13

c) Enlist the advantages of wastewater treatment.

Ans. Advantages of wastewater treatment

The advantages of wastewater treatment are given below:

i. It improves the quality of water.

ii. It makes the water safe for drinking and other purposes, as the pathogens are killed in this process.

iii. Treating wastewater saves aquatic life.

iv. It minimized water borne diseases such as cholera, dysentery, hepatitis etc.

v. Eutrophication does not occur with treated water.

Q.5a) How would you evaluate the effects of water pollution?

Ans. See Question 16

b) Explain how industrial wastes pollute environment?

Ans. See Question 14 (Topic: Industrial Wastes)

c) Support the view that domestic wastes cause pollution.

Ans. See Question 14 (Topic:Household Wastes)

d) How would you relate the agricultural wastes and water pollution?

Ans. See Question 14 (Topic: Agricultural wastes)

Unit 16

Chemical Industries

Q.1 Define the following terms.

- **Metallurgy**
- **Mineral**
- **Ore**
- **Gangue**

Ans. **Metallurgy**

It is the branch of science which deals with the,

- Procedures of extracting metals from their ores
- Purifying metals
- Alloying metals
- Creating useful objects from metals

Metallurgy is the process of extracting valuable metals from their ores, refining the extracted metals into their purest form.

Mineral

The naturally occurring metallic compounds are called minerals.

Metals do not occur in free-state, they occur in combined state. This combined state of various metals is called mineral.

Ore

An aggregate of mineral with other impurities is called ore.

Ore is a naturally occurring solid from which a metal or valuable mineral can be extracted.

Gangue

The earthy materials such as sand, rock, clay and other impurities attached with the ores are called gangue.

Q.2 Describe the basic metallurgical extraction. Also explain the extraction of Copper.

Ans. Various metallurgical processes are use for extracting different types of metals.

The method to be adapted for extracting a specific metal depends upon, the type of the ore, reactivity of the metal to be extracted and nature of the gangue present in the ore.

The basic steps involved in various metallurgical operations are;

- Concentration of ores
- Extraction of metals
- Electro refining or Purification of Metals

Concentration of ores

- The removal of Gangue or matrix from ore is called concentration of ore.
- The process of removal of unwanted material from the ore is called concentration of ore.
- It is the removal of useless rocky portion of the ore
- It is also known as enrichment or dressing or benefaction of the ore.
- Ore is not found in pure metallic state and is found with gangue or matrix.
- Gangue or matrix is the impurities like sand, rocks, limestone etc found with ores.
- Concentration of ores makes it easy to handle the

sample and it reduces the fuel cost.

Procedure

The first step is Crushing and grinding of the huge lumps of ores. It is carried out with the help of crushers or grinders. The second step is pulverization. Pulverization is a process in which the grinded and crushed pieces of ores are brought to fine powdered form with the help of Ball mill or Stamp Mill.

Now the ore can be concentrated with any one of the following method, depending upon the nature of the ore.

- Hand picking
- Hydraulic Washing
- Froth Floatation

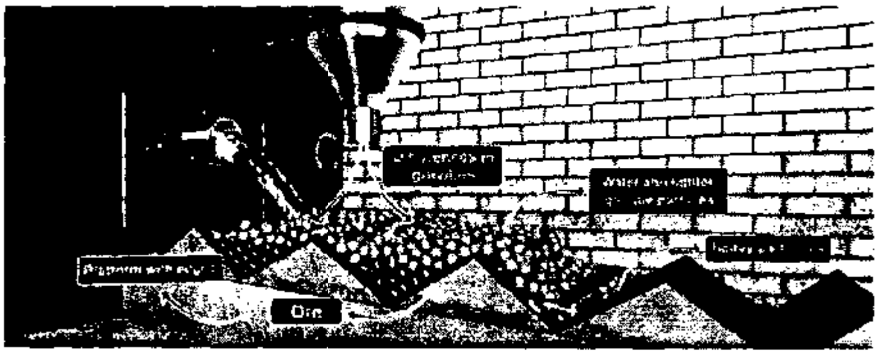
1. **Hand picking**

- It is a physical method in which the ore is concentrated by breaking the rock stones with hammers and selective picking.
- The method can be used only if the ore particles are distinct from gangue and are visible to naked eyes.
- The method is commonly used for the concentration of ores of gold.

2. **Hydraulic Washing**

- It is a gravitational separation method.
- The separation is based on the difference in densities of the ore and gangue.
- The ores particles are poured on a hydraulic classifier.
- Hydraulic classifier is a vibrating inclined table having grooves.
- A jet of water is allowed to flow over it.

- The denser particles settle down in the grooves while the lighter particles are washed away with water.



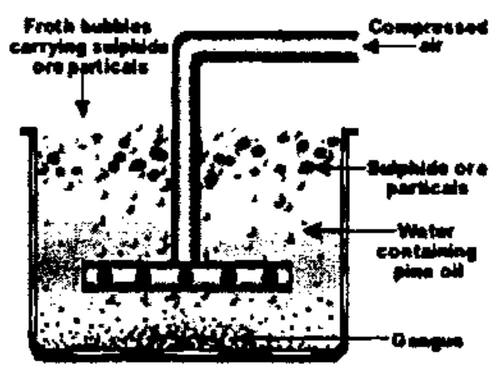
Hydraulic Washing

3. Froth Flotation

It is a Physico-chemical separation process that uses the difference in surface properties of the valuable minerals. This method is especially used for sulphide ores.

The mixture of ore and gangue is wetted with Pine oil and water. Also the mixture along with detergents is agitated with the ore. Froth is produced by blowing a blast of compressed air through the pipe of rotating agitator.

The sulphide ore particles are wetted and coated by pine oil and rise up along with the froth at the top of mixture from where it is collected. The froth is transferred to another container. The froth is washed, dried and clean. The gangue becomes denser by wetting with water and settles down at the bottom.



Froth floatation process

Extraction of metals

The second step after the concentration of ore is

extraction of metal. The gangue has been removed in the first step. Now for the extraction of metal the ore is converted to oxide first.

Conversion of ore to oxide

Ore is converted to oxide because the extraction of metal from its oxide is easy as compare to its sulphides or carbonates.

The following three methods are used for conversion of ore to oxide.

- Roasting
- Smelting
- Bessemerization

1. **Roasting**

Ore can be converted to oxide by roasting. The heating of ore in excess of air in a furnace is called roasting.

Roasting of ore is carried out alone or with other materials at a temperature of 500°C-700°C.Ores of different metals show different behaviour towards oxidation.

Chemical Reactions

For ores of copper, the following possible reactions can take place.

$$CuCO_{3(s)} \xrightarrow{heat} CuO_{(s)} + CO_{2(g)}$$

$$Cu(OH)_{2(s)} \xrightarrow{heat} CuO_{(s)} + H_2O_{(g)}$$

$$2CuFeS_{2(s)} + O_{2(g)} \xrightarrow{heat} Cu_2S_{(s)} + 2FeS_{(s)} + SO_{2(g)}$$

2. **Smelting(Formation of matte)**

A process in which the oxide of ore in the fused state is reduced with reducing agent for obtaining metal is called smelting.

It is the heating and melting of the ore.It is opposite to

roasting, as roasting is oxidation of ore while smelting is reduction of ore.The roasted ore is mixed with a reducing agent such as coke and sand.

The mixture is then smelted in a furnace.As a result the roasted ore is oxidised to Iron oxide (FeO). The iron oxide then reacts with silica (SiO_2) to form silicates.

Chemical Reactions

The following possible reaction can take place

$$2FeS_{(s)} + 3O_{2(g)} \xrightarrow{heat} 2FeO_{(s)} + 2SO_{2(g)}$$

$$FeO_{(s)} + SiO_{2(s)} \longrightarrow FeSiO_3$$

Silicate ($FeSiO_3$) commonly known as slag is lighter, hence collected at the upper hole.

Oxidation of cuprous oxide occurs as given below.

$$2Cu_2S_{(s)} + 3O_{2(g)} \longrightarrow 2Cu_2O_{(l)} + 2SO_{2(g)}$$

Reaction of Copper oxide (Cu_2O) with un-reacted iron sulphide (FeS) takes place.

As a result, cuprous sulphide (Cu_2S) and iron oxide FeO are formed.

The reaction is given as under

$$Cu_2O_{(s)} + FeS_{(s)} \longrightarrow Cu_2S_{(s)} + FeO_{(s)}$$

The FeO also reacts with silica (SiO_2) to form iron silicate ($FeSiO_3$) also known as slag.Molten Cuprous sulphide (Cu_2S) with iron sulphide (FeS) is called matte and is removed through slag hole.

3. Bessemerization

Bessemerization is a process which occurs in a special egg shaped furnace called Bessemer.

Bessemer was invented by Henry Bessemer.The matte formed as a result of smelting process is introduced to

Bessemer converter.A calculated amount of sand is also added to it.

Oxidation of Iron sulphide (FeS) to Iron oxide (FeO) takes place.The iron oxide then reacts with the sand (SiO_2) to form slag ($FeSiO_3$) that floats on the top.

Chemical Reactions

$$2FeS_{(s)} + 3O_{2(g)} \longrightarrow 2FeO_{(s)} + 2SO_{2(g)}$$

$$FeO_{(s)} + SiO_{(s)} \longrightarrow FeSiO_{3(l)}$$

Similarly the cuprous sulphide (Cu_2S) is converted to cuprous oxide (Cu_2O).

The cuprous oxide Cu_2O) then reacts with the cuprous sulphide (Cu_2S) to produce Copper in molten form and sulphur dioxide (SO_2).

$$2Cu_2S_{(s)} + 3O_{2(s)} \longrightarrow 2Cu_2O_{(s)} + 2SO_{2(g)}$$

$$2Cu_2O_{(s)} + Cu_2S_{(s)} \longrightarrow 6Cu(l) + SO_{2(g)}$$

The copper formed is called blister copper due to its porous surface.The porous surface is due to the escape of sulphur dioxide (SO_2) gas during solidification.The copper produced is 95 to 97% pure copper as it may have impurities of iron (Fe), manganese (Mn), Silver (Ag) , Gold Au etc.

Electro refining

The process of obtaining pure metal from impure one by the process of electrolysis is called electro-refining.

As the copper formed as a result of Bessemerization is 95 to 97% pure therefore electro-refining of copper is necessary for making it 99.9% pure.

The steps involved in electro refining of copper are given below;

- A large plat of blister copper formed in Bessemer converter is used as cathode.

- A thin rod of pure copper is used as anode.
- Copper sulphate ($CuSO_4$) and dilute H_2SO_4 is used as electrolyte.
- A potential of 1.3 Volt is applied.
- During electrolysis pure copper is deposited on the cathode plates.
- The impurities in the anode settle down as anode mud.

The impurities contain Ag, Au, Pt etc. The copper obtained is 99.9% pure.

Reaction at Anode;

$$\underset{\text{Impure copper}}{Cu_{(s)}} \longrightarrow Cu^{2+} + 2e^-$$

Reaction at cathode;

$$Cu^{2+}_{(aq)} + 2e^- \longrightarrow Cu_{(s)} \qquad \text{99.9\% pure copper}$$

Q.3 Describe the manufacturing of Sodium Carbonate by Solvay's process. OR How soda ash is prepared by Solvay's process?

Ans. <u>Solvay's Process</u>

This process was for the first time introduced by a Belgian Chemical Engineer Frnest Solvay.

It is a method of commercial preparation of sodium carbonate Na_2CO_3 commonly known as washing soda or soda ash and Sodium Bicarbonate ($NaHCO_3$) commonly known as Baking Soda.

Solvay's process is described below;

Raw Materials

The basic material used for preparation of a specific product is called raw material.

The Raw materials used for preparation of Sodium Carbonate are;

- Sodium ChlorideNaCl
- Limestone $CaCO_3$
- Ammonia NH_3
- Water H_2O

Basic reactions

The reactions used for manufacturing Sodium carbonate are;

i. **Preparation of Brine**

Solution of sodium chloride in water is called Brine. The first step in Solvay's Process is the preparation of Brine Solution.

ii. **Preparation of Ammonical Brine**

The brine solution in which ammonia is dissolved is called Ammonical Brine.Ammonical brine is prepared by introducing brine solution into an ammoniating tower.Mushrooms shaped baffles fitted in the tower ensure proper mixing of brine and ammonia.

iii. **Preparation of Carbon dioxide and slaked lime**

Calcium carbonate is decomposed to calcium oxide (quick lime) and carbon dioxide.The process is carried out in a limekiln.

Chemical Reaction

The reaction is given as under.

$$CaCO_{3(s)} \longrightarrow CaO_{(s)} + CO_{2(g)}$$

The carbon dioxide produced is carried to carbonating tower.Slaked lime is produced by mixing quick lime (CaO) and Water.

$$CaO_{(s)} + H_2O_{(l)} \longrightarrow \underset{\text{Slaked lime}}{Ca(OH)_2}$$

The slaked lime will be used for recovery of ammonia.

iv. Carbonating Tower

Carbonating tower is also known as Solvay tower.In this tower ammonical brine is mixed with carbon dioxide gas.As a result ammonium carbonate $(NH_4)_2CO_3$ is formed.

Chemical Reaction

The reaction is given below.

$$2NH_{3(g)} + H_2O + CO_{2(g)} \longrightarrow (NH_4)_2CO_{3(aq)}$$

The ammonium carbonate then reacts with sodium chloride to form Sodium bicarbonate($NaHCO_3$) and Ammonium Chloride (NH_4Cl).

$$(NH_4)_2CO_{3(aq)} + NaCl_{(s)} \longrightarrow NaHCO_3 + NH_4Cl_{(aq)}$$

Ammonium chloride will be used for recovering ammonia.As the above reaction is exothermic reaction and solubility of sodium bicarbonate ($NaHCO_3$) increases with increase in temperature.Therefore to get a precipitate of Sodium bicarbonate the temperature is decreased to 15^0C.

v. Filtration of precipitate

Precipitated sodium bicarbonate is obtained through filtration from carbonating tower.

vi. Calcinations

Filtered sodium bicarbonate is introduced to a rotary furnace called Calciner for conversion to anhydrous Sodium carbonate (Na_2CO_3).

Chemical Reaction

$$2NaHCO_3 \xrightarrow{heat} Na_2CO_{3(s)} + CO_{2(g)} + H_2O_{(g)}$$

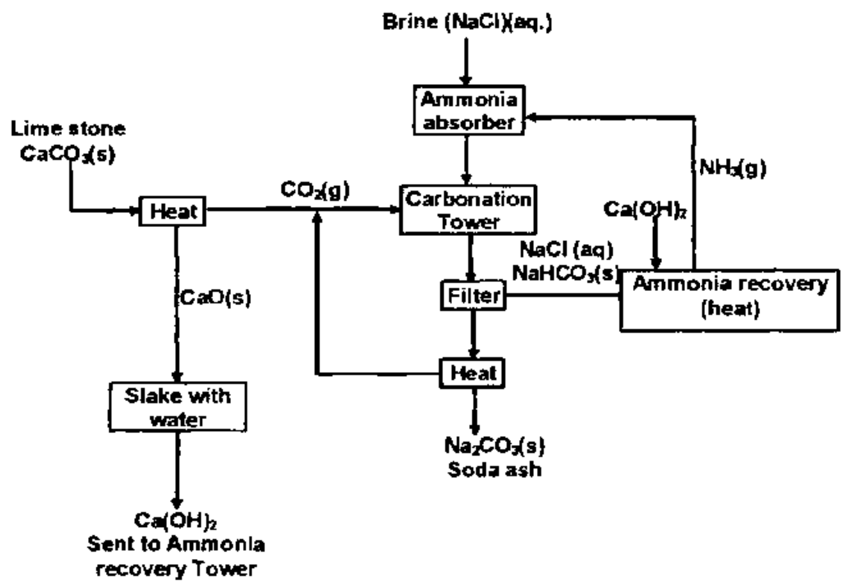
Carbon dioxide is re-circulated in carbonating tower.

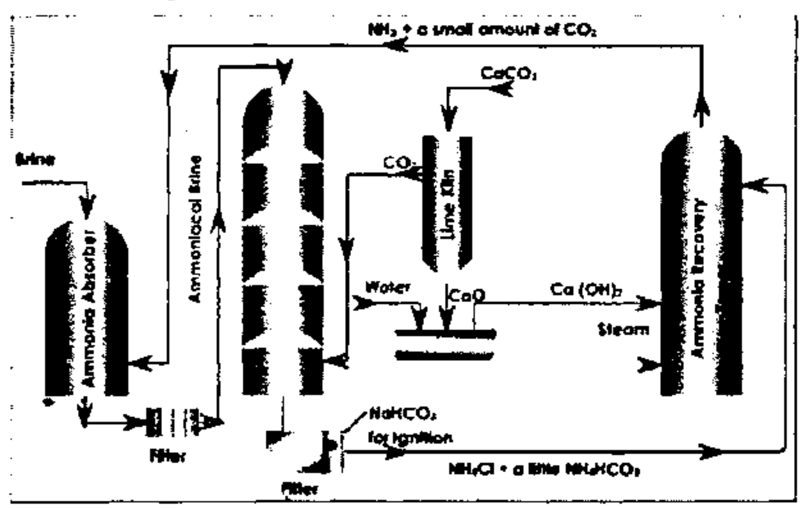
vii. Recovery of Ammonia

The slaked lime $Ca(OH)_2$ produce in step iii and Ammonium chloride NH_4Cl in step iv are heated for the recovery of ammonia

$$Ca(OH)_2 + 2NH_4Cl \longrightarrow CaCl_2 + 2NH_3 + 2H_2O_{(l)}$$

Flow sheet diagram





Preparation of sodium carbonate by Solvay's process

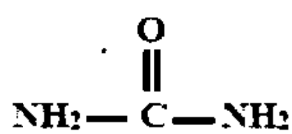
Q.4 What is Urea? Describe its Composition.

Ans. Urea

Urea is commonly known as carbamide.The formula of urea is NH_2CONH_2It is used as fertilizer for the growth of plants.

For the first time urea was prepared by Friedrich Wohler in 1828 from inorganic compound ammonium cyanate (NH_4CNO).

Structural formula



Composition of Urea

It is the most common nitrogen containing fertilizer.The percentage of nitrogen is Urea is 46.67%.It readily dissolves in water and leaves no residues in crops after use.The percentage composition is given in the given table.

Elements	Percentage (%)
Nitrogen (N)	46.67
Oxygen(O)	26.67
Carbon (C)	20.00
Hydrogen (H)	6.66

Q.5 Write down the raw materials used for manufacturing of Urea. How these raw materials are prepared? Also write down the basic reactions in involved in the manufacturing of urea.

Ans. Raw materials

The raw materials used for manufacturing urea are;

- Ammonia

- Carbon dioxide

Preparation of Ammonia (NH_3)

Ammonia is prepared by Haber process. The conversion of nitrogen gas (N_2) and hydrogen gas (H_2) to Ammonia (NH_3) by passing both the gases over iron catalyst at 450°C and 200 atm pressures is called Haber process.

Chemical Reactions

$$N_{2(g)} + 3H_{2(g)} \underset{200\,atm}{\overset{450\,^{\circ}C}{\rightleftharpoons}} 2NH_{3(g)}$$

Nitrogen for this process is obtained from fractional distillation of air. Hydrogen is prepared by passing methane and steam over heated nickel as catalyst.

Preparation of Carbon dioxide

Carbon dioxide is obtained from natural gas.

$$CH_{4(g)} + H_2O_{(g)} \xrightarrow{Ni} CO_2(g) + 3H_{2(g)}$$

Basic Reactions

The following reactions take place in the manufacturing of urea.

i. **Reaction of ammonia and Carbon dioxide**

Ammonium carbamate (NH_2COONH_4) is obtained by heating Ammonia and carbon dioxide at 170-200°C and at a pressure of 200atm.

The reaction is given as under;

$$2NH_{3(g)} + CO_2 \underset{200atm}{\overset{200\,^{\circ}C}{\rightleftharpoons}} {}_{(g)}\underset{\text{Ammonium Carbamate}}{NH_2COONH_4}$$

ii. Urea Formation

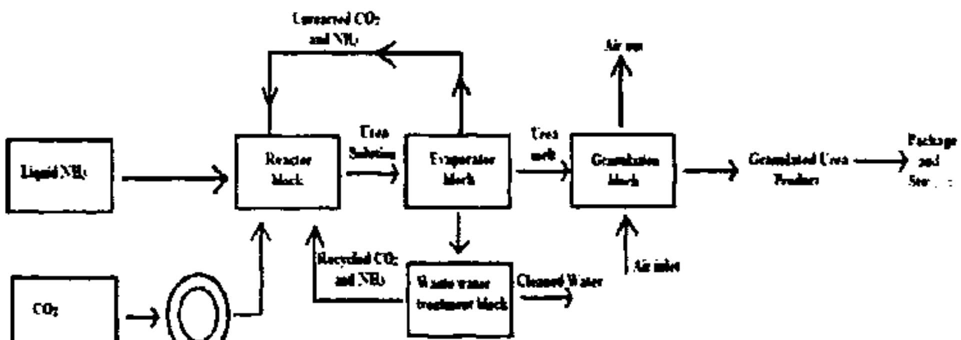
Ammonium carbamate is decomposed to Urea and H_2O on heating.

$$NH_2COONH_4 \xrightarrow{heat} NH_2CONH_{2(l)} + H_2O$$

iii. Evaporation and Granulation

The urea formed is concentrated in vacuum evaporators by evaporating water from it.It is then granulated in the granules tower.After granulation Urea is stored for marketing.

Flow sheet diagram



Manufacturing Urea Flow sheet diagram

Q.6 Describe the uses of Urea.

Ans. Uses of Urea

The uses of urea are given below.

- It is used as fertilizer.
- Urea formaldehyde resins are used as plywood adhesives/glues.
- Melamine formaldehyde resins are used as dinnerware.
- Highly explosive compound Urea nitrate is prepared from urea.

- It is used as raw material for the production of plastics, resins, adhesives etc.
- It is used as flame proofing agent.
- It is used in air conditioners, facial cleaners, hair removing creams and lotions.
- It is used for de-icing roads as it does not promote corrosion while rock salt does.
- It is used as flavour enhancing additives in cigarettes
- It is used in skin relating products for rehydration of skin.

Q.7 Calculate the percentage of Nitrogen in Urea.

Ans. Percentage calculation of Nitrogen

Formula of urea $= NH_2CONH_2$

Molar mass = 60.01 g/mol

Atomic mass of N = 14

Number of atoms = 2

Molecular mass of urea = 60.1

To find

Percentage of Nitrogen = ?

Solution

We know that,

Percentage=

$$\frac{\text{Atomic mass of element} \times \text{No.of atoms in a compound}}{\text{Molecular mass of the compound}} \times 100$$

$$\text{Percentage} = \frac{14 \times 2}{60.01} \times 100 = \frac{28}{60.01} \times 100$$

Percentage= 46.66%

Q.8 Compare synthetic fertilizer and natural fertilizer/ organic fertilizer.

Ans. <u>Differentiate synthetic and natural fertilizers</u>

Synthetic Fertilizers	Organic / Natural Fertilizers
Synthetic fertilizers are manufactured from Natural Gas or Petroleum.	Organic fertilizers are derived from the death and decay of plants and animals wastes.
They are granular and dissolve readily in water.	They are non granular and dissolve slowly in water.
They are artificially prepared.	They are prepared naturally.
They are used instantly by plants through leaching process.	They are naturally decomposed slowly by soil microbes. They are used for the entire season.
Their N.P.K ratio is 20-60%.	Their N.P.K ratio is 14%.
They contain mostly three essential nutrients required for the plants.	They contain a wide range of natural nutrients required for the plants.
They do not improve water holding capacity.	They improve water holding capacity.
They do not reduce soil erosion and soil crusting problems.	They reduce soil erosion and soil crusting problems
They contain equal distribution of N.P.K.	They have unequal distribution of N.P.K.
They have more nutrients, cheaper and easily available.	They have fewer nutrients, may be expensive and are not easily available.
They seep deep into the soil with watering the fields.	They are present on the surface of earth and do not mix with soil easily.
They immediately release nutrients.	They slowly release nutrients.
They are basic in nature and	They may be acidic in nature and

neutral to skin.	may burn the skin.

Q.9 Write a brief note on petroleum. Also discuss the origin and occurrence of petroleum.

Ans. Petroleum

The word petroleum is derived from Lain words "Petro" which means "Rock" and "oleum" which means "oil". It is also called liquid gold.It is crude oil.It is dark viscous liquid and present inside the earth.They are composed of hydrocarbons.

Origin of Petroleum

The two theories about the origin of petroleum are;

- Inorganic or Abiotic origin
- Biotic origin

Inorganic/Abiotic Origin

The theory that petroleum is produced by the reaction of steam with metallic carbides at high temperature and pressure under the surface of earth is called theory of inorganic/abiotic origin.This theory was put forward by a Russian chemist Mendeleev.

Organic origin

It is the popular theory regarding the origin of petroleum.

According to this theory,

- Petroleum is formed by the action of bacteria on dead organic matters of plants and animals, under the high temperature and pressure of earth.
- These dead organic matters have been buried deep inside the earth millions of years ago.
- These deposits have been trapped between the layers

of non-porous rocks and thus the oil and gas could not come out rather collected inside the earth.

Occurrence of Petroleum

Petroleum deposits are unequally distributed throughout the world. They are found at a depth of 200-1000 feet. The richest deposits of petroleum are located in Saudi Arabia, Iran, U.A.E and other Middle East countries. Petroleum is also found in central African states such as Libya, Nigeria, Canada and U.S.A.

Petroleum deposits in Pakistan are found in;

- Meyal and Tut in Potohar areas of Punjab.
- Badin and Hyderabad districts of Sindh.
- Kohat and Karak districts of Khyber Pakhtunkhwa.

It exists in all three states of matter.

- In the solid form it is called **asphalt.**
- In the liquid state it is called **crude oil.**
- In gaseous state it is called **natural gas.**

Q.10 What is meant by drilling of petroleum?

Ans. **Drilling of petroleum**

- The art and science of mining a hole in the earth crusts or rocks is called drilling.
- Petroleum is present at a depth of about 500 feet inside the earth.
- It is present inside the earth is in liquid form and is called crude oil.
- It is often associated with natural gas, natural gas exerts pressure to drives the petrol out.
- Artificial mining or drilling is a process of mining bores inside the earth.

- While mining petroleum when the oil pocket is pierced the natural gas pressure forces the oil out.
- If natural gas is not present with the petroleum then air pressure is used for driving out petroleum.
- The oil obtained from the earth is carried out in pipes to the refineries for refining.

Q.11 What is oil refinery?

Ans. Oil refinery

It is a plant where useful products, such as gasoline, diesel fuel, asphalt, kerosene, liquefied petroleum gas etc. are separated from crude oil. The oil obtained from the earth is not in pure state. It must be refined before using it for various purposes.

Famous oil refineries of Pakistan are

- Pak-Arab Refinery Ltd.
- National Refinery Ltd.
- Attock Refinery Ltd.

Q.12 What is asphalt?

Ans. Asphalt

- Petroleum in solid state is generally called asphalt.
- Petroleum crude oil is a complex mixture of different hydrocarbons.
- Asphalt is a component of petroleum/crude oil.
- It is separated from the crude oil by fractional distillation process.
- It is a highly viscous liquid or semi-solid.
- Asphalt is a higher hydrocarbon containing more than 70 carbons.

Q.13 What do you know about the fractional distillation of petroleum?

Ans. **Fractional Distillation of petroleum**

- It is a method of separating various hydrocarbons on the bases of difference in their boiling points.
- Crude oil obtained from earth is impure and is a mixture of wide range of compounds especially hydrocarbons.
- The separation of various pure products from the crude oil on the bases of their different boiling point range is called refining.
- Petroleum is refined in a tall column containing fractions known as fractionating column.
- Crude oil is heated at 400^0C and then it is passed through fractionating column.
- The vapours of different compounds are condensed in different fraction based on their boiling points and hence separated from crude oil.

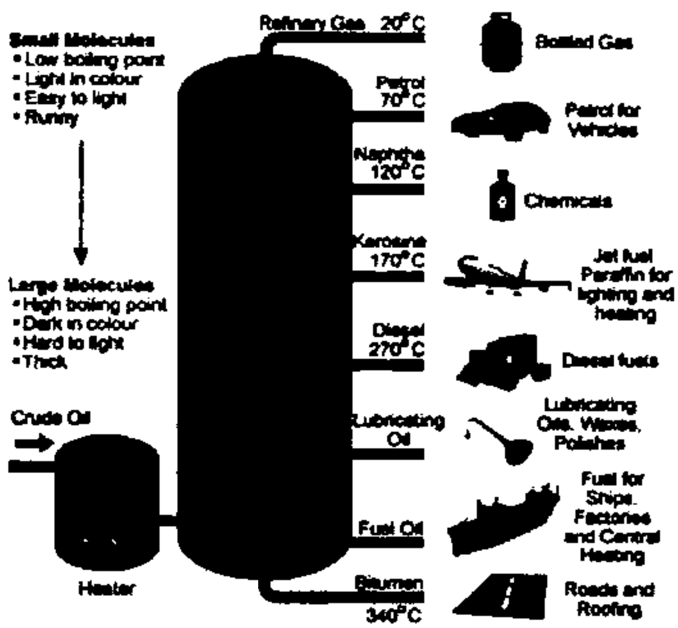


Table of Fractions of petroleum and their important uses

S.No.	Fractions	Number of carbon atoms per molecule	Boiling point	Uses
1	Refinery Gas	C_1 to C_4	Below 40°C	Methane gas is used for cooking food. Ethan is also used as fuel. Others are used as LPG.
2	Gasoline	C_4 to C_{12}	40 to 130 °C	Used as raw material for organic compounds. Used as light engine oil.
3	Kerosine oil	C_{10} to C_{16}	150 to 200°C	Used for domestic heating fuel. Used in air craft jet fuel
4	Diesel oils	C_{14} to C_{25}	225 to 300 °C	Used as fuel in large vehicles, Used for cracking to make petrol
5	Lubricating oil	C_{20} to C_{70}	300 to 400 °C	Used as lubricants.
6	Residue	Above C_{70}	Above 400°C	Used for carpeting roads, Used as roofing and water proofing materials.

EXERCISE

A. Choose the correct option.

1. When sodium bicarbonate is heated to get sodium carbonate , all are produced except

   a. CO　　b. CO_2

   c. Na_2CO_3　　d. H_2O

2. Forth flotation process is concentration of ore by
   a. Magnetically b. Wetting the ore
   c. Difference in density d. Chemically
3. All are the raw materials for the manufacturing of soda ash except
   a. Ammonia b. Brine
   c. Lime stone d. Carbon monoxide
4. Matte is a mixture of
   a. CuS and FeS b. Cu_2S and FeS
   c. Cu_2O and FeS d. Cu_2O and FeO
5. The impurity present in mineral is called
   a. Metal b. Ore
   c. Gangue d. Salt
6. All are the raw materials for the manufacturing of urea except
   a. CO_2 b. NH_3
   c. H_2O d. NaCl
7. Percentage of nitrogen in urea is
   a. 14 b. 28
   c. 60 d. 46
8. Blister copper is refined through
   a. Concentration b. Reduction
   c. Smelting d. Electrolysis
9. Petroleum is separated into different fractions by the process of
   a. Simple distillation b. Condensation
   c. Fractional distillation d. Destructive distillation

10. All steps are used for the extraction of metals except
    a. Roasting b. Smelting
    c. Evaporation d. Bessmiraization

ANSWERS:

1	a	2	b	3	d	4	b	5	c
6	d	7	d	8	d	9	c	10	C

B. Write short answers to the following questions.

1. How could you convert $NaHCO_3$ into Na_2CO_3?

Ans. Sodium Bicarbonate ($NaHCO_3$) can be converted to sodium carbonate (Na_2CO_3) by heating sodium bicarbonate in a rotary furnace called Calciner.The reaction is given as under.

$$2NaHCO_3 \xrightarrow{heat} Na_2CO_{3(s)} + CO_{2(g)} + H_2O_{(g)}$$

2. Enlist different uses of urea.

Ans. See Question 6

3. Differentiate between mineral and ores.

Ans. <u>Differentiate between mineral and ores:</u>

Mineral	Ore
The naturally occurring metallic compounds are called minerals.	An aggregate of minerals with other impurities is called ore
All minerals are ores.	All ores are not minerals.
For example; Clay is the mineral of Aluminum	For example; Bauxite is the ore of Aluninum

4. Define Metallurgy. What are its steps?

Ans. <u>Metallurgy</u>

It is the branch of science which deals with the,

- Procedures of extracting metals from their ores
- Purifying metals
- Alloying metals
- Creating useful objects from metals

Metallurgy is the process of extracting valuable metals from their ores, refining the extracted metals into their purest form.

Steps of Metallurgy

The basic steps involved in various metallurgical operations are;

- Concentration of ores
- Extraction of metals
- Electro refining or Purification of Metals

5. What is the function of the froth flotation process?

Ans. **Function of Froth flotation process**

Froth flotation process is a Physico-chemical separation process that uses the difference in surface properties of the valuable minerals. The function of froth flotation process is concentration of ore by removing the impurities. The impurities removed are known as gangue.

Thus we can say that the removal of gangue from ore is the main function of froth flotation process.

6. On what basis the different fractions of petroleum are separated?

Ans. The different fractions of petroleum are separated on the bases of difference in theirboiling points. Petroleum is heated at 400^0C and then it is introduced to fractionating column. Fractionating column is a tall column containing fractions. The vapours of different

compounds are condensed in different fraction based on their boiling points and hence separated from crude oil.

7. What is slaked lime? How slaked lime is produced?

Ans. Calcium hydroxide (CaOH) is commonly known as slaked lime. It is produced by the reaction of Calcium Oxide (CaO) commonly known as quick lime and water. The reaction is given as under.

$$CaO_{(s)} + H_2O_{(l)} \longrightarrow \underset{\text{Slaked lime}}{Ca(OH)_2}$$

8. Assess the composition of urea and calculate the percentage of nitrogen in it.

Ans. See Question 4 Topic composition and Question 7 for percentage calculation.

9. What is gangue and where it is found?

Ans. The earthy materials such as sand, rock, clay and other impurities attached with the ores are called gangue. Gangue is the unwanted impurities present with ore. It is found inside the earth with ore. Gangue is separated from the ore for extraction of pure metal.

10. How blister copper is purified?

Ans. See Question 2 Topic: Electro refining

C. Write detailed answers to the following questions.

Q.1a) How could you convert the concentrated ore to its oxide?

Ans. See Question 2 Topic:Conversion of ore to oxide

b) How would you use the roasting in extraction of copper?

Ans. See Question 2 Topic:Roasting

c) What inference can you make of smelting in extraction of copper?

Ans. See Question 2Topic:Smelting

d) Can you elaborate the reason of electro-refining of copper?

Ans. See Question 2Topic:Electro-refining

Q.2 a) List the raw materials used in Solvay process.

Ans. See Question 3 Topic:Raw Materials

b) What basic reactions would you use to support the manufacturing of soda ash?

Ans. See Question 3 Topic:Basic reactions

c) Predict the by-products in the Solvay process.

Ans. Byproduct in Solvay process

The major by-product produced in the Solvay process is calcium chloride ($CaCl_2$) in aqueous solution. It is formed as a result of reaction between slaked lime $Ca(OH)_2$ produce and Ammonium chloride NH_4Cl. The ammonia formed is recovered for using in the Solvay process again.

$$Ca(OH)_2 + 2NH_4Cl \longrightarrow CaCl_2 + 2NH_3 + 2H_2O_{(l)}$$

d) Sketch the flow sheet diagram of the Solvay process.

Ans. See Question 3 Topic: Flow-sheet diagram

Q.3a) Enlist raw materials used in the manufacture of urea.

Ans. See Question 5 Topic: Raw materials

b) What basic reactions would you use to support the manufacture of urea?

Ans. See Question 5 Topic:Basic reactions

c) What is the advantage of recycling of un-reacted compound of in manufacture of urea?

Ans. Advantage of recycling

The basic raw materials used in the manufacturing of urea are Carbon dioxide (CO_2) and Ammonia (NH_3). Ammonia is prepared by Haber process and Carbon dioxide is prepared from Natural gas. Both are expensive processes. Thus recycling these un-reacted compounds is a cost effective method for the production of Urea. Upon recycling the un-reacted ammonia and carbon dioxide are once again subjected to reaction and the following reaction takes place.

$$2NH_{3\,(g)} + CO_{2\,(g)} \underset{200atm}{\overset{200\,^{0}C}{\rightleftharpoons}} \underset{\text{Ammonium Carbamate}}{NH_2COONH_4}$$

d) Sketch the flow sheet diagram of the urea manufacture process.

Ans. See Question 5 Topic: Flow sheet diagram

Q.4a) Define refining of petroleum. Describe the composition of petroleum.

Ans. Refining of petroleum

Crude oil obtained from earth is impure and is a mixture of wide range of compounds especially hydrocarbons. The separation of various pure products from the crude oil on the bases of their different boiling point range is called refining of petroleum. Petroleum is refined in a tall column containing fractions known as fractionating column. Crude oil is heated at $400^{0}C$ and then it is passed through fractionating column. The vapours of different compounds are condensed in different fraction based on their boiling points and hence separated from crude oil.

b) What are the two theories about the origin of petroleum?

Ans. See Question 9 Topic: Origin of petroleum

c) Write a detail note on fractional distillation of petroleum.

Ans. See Question 13

Q.5 a) Write a detail note on metallurgical operations.

Ans. See Question 2

b) Explain the process of smelting and bessemerization with reference to copper extraction.

Ans. See Question 2 Topic: Bessemerization and smelting

c) Enlist the different uses of urea.

Ans. See Question 6